(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 148 663 B1

(12) # EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
31.03.2010 Bulletin 2010/13

(51) Int Cl.:
H04B 7/26 *(2006.01)* ***H04W 16/00*** *(2009.01)*

(21) Application number: **01303654.6**

(22) Date of filing: **20.04.2001**

(54) **Radio base station and frame configuration method using TDMA scheme and SDMA scheme**

Radio Basisstation und Konfigurationsmethode für Rahmen unter Verwendung von TDMA und SDMA Verfahren

Station de base radio et méthode de configuration de trame uitilisant un schéma TDMA et SDMA

(84) Designated Contracting States:
DE FR GB

(30) Priority: **21.04.2000 JP 2000120633**

(43) Date of publication of application:
24.10.2001 Bulletin 2001/43

(73) Proprietor: **KABUSHIKI KAISHA TOSHIBA**
Kawasaki-shi,
Kanagawa-ken 210-8572 (JP)

(72) Inventors:
- **Toshimitsu, Kiyoshi,**
  Int. Property Division
  Tokyo (JP)
- **Tamada, Yuzo,**
  Int. Property Division
  Tokyo (JP)
- **Kasami, Hideo,**
  Int. Property Division
  Tokyo (JP)

(74) Representative: **Midgley, Jonathan Lee**
Marks & Clerk LLP
90 Long Acre
London
WC2E 9RA (GB)

(56) References cited:
WO-A-98/16077 WO-A-98/30047
WO-A-99/22547 WO-A-99/26425

- **TORSNER J ET AL: "Radio network solutions for HIPERLAN/2" VEHICULAR TECHNOLOGY CONFERENCE, 1999 IEEE 49TH HOUSTON, TX, USA 16-20 MAY 1999, PISCATAWAY, NJ, USA, IEEE, US, 16 May 1999 (1999-05-16), pages 1217-1221, XP010342076 ISBN: 0-7803-5565-2**
- **SINHA R ET AL: "Forward link capacity in smart antenna base stations with dynamic slot allocation" PERSONAL, INDOOR AND MOBILE RADIO COMMUNICATIONS, 1998. THE NINTH IEEE INTERNATIONAL SYMPOSIUM ON BOSTON, MA, USA 8-11 SEPT. 1998, NEW YORK, NY, USA,IEEE, US, 8 September 1998 (1998-09-08), pages 942-946, XP010314596 ISBN: 0-7803-4872-9**

EP 1 148 663 B1

Description

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

[0001] The present invention relates to a radio base station for carrying out radio communications with a plurality of radio terminals by adopting both a time division multiple access scheme and a space division multiple access scheme, and a frame configuration method for the radio base station.

DESCRIPTION OF THE RELATED ART

[0002] In recent years, demands for the radio data communications are increasing, and in conjunction with this, requests for allocating necessary radio bandwidths to respective radio terminals are also increasing. In order to make the radio bandwidths to be allocated to respective radio terminals variable, there is a need for a scheduler that makes radio bandwidth allocation adjustment among users. For example, a HIPERLAN2 proposed in the ESTI-BRAN (European Tele communications Standards Institute-Broadband Radio Access Networks) and a HiSWANa (High Speed Wireless Access Network a) proposed in the ARIB-MMAC (Association of Radio Industories and Businesses-Multimedia Mobile Access Communication systems) are radio systems of the centralized control type in which a MAC (Media Access Control) of the radio base station determines a frame configuration of each frame and broadcasts it to the radio terminal. For this reason, the HIPERLAN2 and HiSWANa are applicable not only to the radio LAN but also to a subscriber radio system called FWA (Fixed Wireless Access).

[0003] On the other hand, in order to utilize the limited radio frequencies effectively, a scheme called SMDA (Space Division Multiple Access) has been proposed recently. This is a scheme for suppressing interferences among radio terminals by controlling the antenna directivity. In this scheme, the radio base station is required to have one or more modulation/demodulation units in order to enable communications with different radio terminals at the same time using the same frequency.

[0004] However, up to now, there has been no proposition for a specific frame configuration method suitable for the case where a plurality of modulation/demodulation units are provided in a radio base station that carries out radio communications in the TDMA (Time Division Multiple Access) scheme using a frame configuration.

[0005] Sinha et al "Forward link capacity in smart antenna base stations with dynamic slot allocation", the 9th IEEE International Symposium "Personal, indoor and mobile radio communications 1998". New York, pages 942-946 describes a set of mobile stations communicating with a base station equipped with a smart antenna operating in multi beam packed switched SDMA mode.

BRIEF SUMMARY OF THE INVENTION

[0006] It is therefore an object of the present invention to provide a radio base station and a frame configuration method capable of making communication bandwidths to be allocated to respective radio terminals variable at a time of carrying out radio communications with respect to a plurality of radio terminals by adapting both the TDMA scheme and the SMDA scheme.

[0007] According to one aspect of the present invention there is provided a radio base station for transferring signals of time division multiplexed frames with respect to a plurality of radio terminals, the radio base station comprising:

a beam formation unit configured to form a plurality of space dividing beams simultaneously;
a plurality of antenna elements configured to transfer the signals with respect to the radio terminals by transmitting the plurality of space dividing beams towards the radio terminals;
a scheduling processing unit configured to allocate communication bandwidths to the radio terminals such that there is substantially no mutual interference among those signals to be transferred by different frames, with respect to a plurality of frames that are corresponding to at least one of the plurality of space dividing beams,
a memory unit configured to store weights respectively corresponding to the radio terminals, that are to be used in forming the plurality of space dividing beams, and
a weight control unit configured to set the weights to the beam formation unit,
wherein the scheduling processing unit is configured to allocate communication bandwidths of an identical time in different frames to different radio terminals such that there is substantially no mutual interference among those signals to be transferred at the identical time with respect to the different radio terminals according to the weights corresponding to the different radio terminals as stored in the memory unit, and is then configured to allocate entire frame configuration information indicating frame configurations of all the time division multiplexed frames to one of the time division multiplexed frames.

[0008] According to another aspect of the present invention there is provided a radio base station for transferring signals of time division multiplexed frames with respect to a plurality of radio terminals, the radio base station comprising:

a beam formation unit configured to form a plurality of space dividing beams simultaneously;
a plurality of antenna elements configured to transfer the signals with respect to the radio terminals by transmitting the plurality of space dividing beams to-

ward the radio terminals; and

a scheduling processing unit configured to allocate communication bandwidths to the radio terminals such that there is substantially no mutual interference among those signals to be transferred by different frames, with respect to a plurality of frames that are corresponding to at least one of the plurality of space dividing beams,

a memory unit configured to store weights respectively corresponding to the radio terminals, that are to be used in forming the plurality of space dividing beams and

a weight control unit configured to set the weights to the beam formation unit,

wherein the scheduling processing unit is configured to allocate communication bandwidths in different frames to different radio terminals such that there is substantially no mutual interference among those signals to be transferred with respect to the different radio terminals according to the weights corresponding to the different radio terminals as stored in the memory unit, and allocates a next communication bandwidth to a frame for which a total sum of allocated communication bandwidths is the smallest among the time division multiplexed frames; and

wherein the scheduling processing unit is configured to allocate a plurality of frame configuration information each indicating a frame configuration of a respective time division multiplexed frame, to corresponding ones of the time division multiplexed frames respectively.

[0009] According to another aspect of the present invention there is provided a frame configuration method for time division multiplexed frames to transfer signals between a radio base station and a plurality of radio terminals, the frame configuration method comprising:

(a) allocating communication bandwidths of an identical time in different frames to different radio terminals such that there is substantially no mutual interference among those signals to be transferred at the identical time with respect to the different radio terminals according to weights respectively corresponding to the different radio terminals, that are used in forming a plurality of space dividing beams for transferring the signals between the radio base station and the radio terminals; and

(b) allocating entire frame configuration information indicating frame configurations of all the time division multiplexed frames to one of the time division multiplexed frames.

[0010] According to another aspect of the present invention there is provided a frame configuration method for time division multiplexed frames to transfer signals between a radio base station and a plurality of radio terminals, the frame configuration method comprising:

(a) allocating communication bandwidths in different frames to different radio terminals such that there is substantially no mutual interference among those signals to be transferred with respect to the different radio terminals according to weights respectively corresponding to the different radio terminals, that are to be used in forming a plurality of space dividing beams for transferring the signals between the radio base station and the radio terminals, and allocating a next communication bandwidth to a frame for which a total sum of allocated communication bandwidths is the smallest among the time division multiplexed frames; and

(b) allocating a plurality of frame configuration information each indicating a frame configuration of a respective time division multiplexed frame, to corresponding ones of the time division multiplexed frames respectively.

[0011] According to another aspect of the present invention there is provided a computer usable medium having computer readable program codes embodied therein for causing a computer to function as a scheduling processing unit in a radio base station for transferring signals of time division multiplexed frames with respect to a plurality of radio terminals, the computer readable program codes include:

a first computer readable program code for causing said computer to allocate entire frame configuration information indicating frame configurations of all the time division multiplexed frames to one of the time division multiplexed frames, or allocate a plurality of frame configuration information each indicating a frame configuration of a respective time division multiplexed frame, to corresponding ones of the time division multiplexed frames respectively; and

a second computer readable program code for causing said computer to allocate communication bandwidths of an identical time in different frames to different radio terminals such that there is substantially no mutual interference among those signals to be transferred at the identical time with respect to the different radio terminals according to weights respectively corresponding to the different radio terminals, that are to be used in forming a plurality of space dividing beams for transferring the signals between the radio base station and the radio terminals, or allocate communication bandwidths in different frames to different radio terminals such that there is substantially no mutual interference among those signals to be transferred with respect to the different radio terminals according to weights respectively corresponding to the different radio terminals, that are to be used in forming a plurality of space dividing beams for transferring the signals between the radio base station and the radio terminals and allocate a next communication bandwidth to a frame for which a total sum of allocated communication bandwidths is the smallest among the time division multiplexed frames.

[0012] The present invention can be implemented either in hardware or on software in a general purpose computer. Further the present invention can be implemented in a combination of hardware and software. The present invention can also be implemented by a single processing apparatus or a distributed network of processing apparatuses.

[0013] Since the present invention can be implemented by software, the present invention encompasses computer code provided to a general purpose computer on any suitable carrier medium. The carrier medium can comprise any storage medium such as a floppy disk, a CD ROM, a magnetic device or a programmable memory device, or any transient medium such as any signal e.g. an electrical, optical or microwave signal.

[0014] Other features and advantages of the present invention will become apparent from the following description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

Fig. 1 is a schematic block diagram showing a configuration of a radio communication system according to one embodiment of the present invention.

Fig. 2 is a block diagram showing a configuration of a radio base station in the radio communication system of Fig. 1.

Fig. 3 is a block diagram showing a configuration of a receiving multi-beam formation circuit in the radio base station of Fig. 2.

Fig. 4 is a block diagram showing a configuration of a receiving beam formation circuit in the receiving multi-beam formation circuit of Fig. 3.

Fig. 5 is a block diagram showing a configuration of a transmitting multi-beam formation circuit in the radio base station of Fig. 2.

Fig. 6 is a block diagram showing a configuration of a transmitting beam formation circuit in the transmitting multi-beam formation circuit of Fig. 5.

Fig. 7 is a diagram showing a general TDMA/TDD frame configuration.

Fig. 8 is a diagram showing exemplary broadcast channel contents that can be used in the radio communication system of Fig. 1.

Fig. 9 is a diagram showing a frame configuration that can be used in the radio communication system of Fig. 1 in the case of ONE-FCH.

Fig. 10 is a block diagram showing a modified configuration of a MAC unit in the radio base station of Fig. 2.

Fig. 11 is a diagram showing a frame configuration that can be used in the radio communication system of Fig. 1 in the case of PLURAL-FCH.

Figs. 12A and 12B are diagrams for explaining differences between the frame configuration of Fig. 9 and the frame configuration of Fig. 11.

Fig. 13 is a flow chart showing a processing procedure of a first frame configuration scheduling method using ONE-FCH according to one embodiment of the present invention.

Fig. 14 is a diagram showing antenna directivities of the radio base station of Fig. 2 with respect to three radio terminals.

Figs. 15A. 15B and 15C are diagrams showing states of communication bandwidth allocation with respect to three frames according to the first frame configuration scheduling method of Fig. 13.

Fig. 16 is a flow chart showing a processing procedure of a second frame configuration scheduling method using ONE-FCH according to one embodiment of the present invention.

Figs. 17A and 17B are diagrams showing states of communication bandwidth allocation with respect to three frames according to the second frame configuration scheduling method of Fig. 16.

Fig. 18 is a diagram showing antenna directivity of the radio base station of Fig. 2 with respect to a radio terminal group.

Fig. 19 is a flow chart showing a processing procedure of a frame configuration scheduling method using PLURAL-FCH according to one embodiment of the present invention.

Figs. 20A and 20B are diagrams showing states of communication bandwidth allocation with respect to three frames according to the frame configuration scheduling method of Fig. 19.

DETAILED DESCRIPTION OF THE INVENTION

[0016] Referring now to Fig. 1 to Figs. 20A and 20B, one embodiment of a radio base station and a frame configuration method according to the present invention will be described in detail. Note that the same or similar elements are given the same or similar reference numerals in these figures.

[0017] Fig. 1 shows a configuration of a radio communication system using a radio base station according to this embodiment. As shown in Fig. 1, the radio base station 10 of this embodiment has an antenna device 14 which is formed by a plurality of antenna elements 12 and capable of forming a plurality of beam patterns, a modulation unit (not shown) for modulating transmission data, and a demodulation unit (not shown) for demodulating received radio signals. Of course, it is also possible to use a configuration using a modulation/demodulation unit in which the modulation unit and the demodulation unit are integrated. Then, a plurality of beam areas 16 formed by the beam patterns of the radio base station 10 constitute a service area 18 of this communication system. The radio base station 10 executes transmission/reception of radio signals with respect to a radio terminal 20 having a radio signal transmission/reception function which is located within the service area 18, by forming a plurality of beam patterns.

[0018] Fig. 2 shows a detailed configuration of the radio base station 10 according to this embodiment. As shown in Fig. 2, the radio base station 10 of this embodiment has a MAC (Media Access Control) unit 1001 for carrying out assembling of frames to be utilized for transmission/reception of radio signals with respect to the radio terminal 20 and allocation of communication bandwidths to these frames. Then, the MAC unit 1001 is provided with a scheduling processing unit 1012 for from configuration and a memory unit 1013 for storing terminal information of each radio terminal 20, for the purpose of realizing the function of the MAC unit 1001. In Fig. 2, the number of antenna elements 12 in the antenna device 14 is assumed to be four and the antenna device 14 is assumed to be shared by a transmitting side and a receiving side, for the sake of the simplicity.

[0019] As shown in Fig. 2, switches 1006 are connected to the antenna elements 12 in correspondences to respective antenna elements. Then, the switching between transmission and reception of the antenna device 14 is realized by switching the switches 1006.

[0020] In the receiving side, the signals received by the antenna elements 12 are entered into amplifiers (low noise amplifiers) 1007 corresponding to the respective antenna elements 12 through the switches 1006. The entered received signals are amplified by the amplifiers 1007.

[0021] The amplified received signals are applied with a frequency conversion from an RF band into an IF band or a baseband by frequency converters 1008. In this IF band or the baseband, the receiving multi-beam formation circuit 1009 forms a plurality of receiving beams simultaneously by carrying out a prescribed weighting with respect to each received signal outputted by each frequency converter 1008. This weighting is executed according to a weighting control device 1011.

[0022] Fig. 3 shows a detailed configuration of the receiving multi-beam formation circuit 1009 of Fig. 2. In Fig. 3, the number of beams to be simultaneously formed is assumed to be three. The received signals outputted from each frequency converter 1008 are entered into a corresponding receiving beam formation circuit 1014 (1014a, 1014b, 1014c). Each receiving beam formation circuit 1014 combines the entered received signals by weighting them according to weights set by the weight control device 1011. Then, each receiving beam formation circuit 1014 outputs weighted and combined signals to a corresponding demodulation unit 1010.

[0023] Fig. 4 shows a detailed configuration of a receiving beam formation circuit 1014 of Fig. 3. The received signals outputted from each frequency converter 1008 are entered into a corresponding weighting circuit 1015, where the prescribed weighting is carried out. Here, the method of weighting at the weighting circuit 1015 can be an amplitude weighting, a phase weighting, or an amplitude and phase weighting, for example. The weighted received signals are them combined by a combiner 1016.

[0024] On the other hand, in the transmitting side, the transmission signals modulated by the modulation units 1002 are outputted to the transmitting multi-beam formation circuit 1003 as shown in Fig. 2. The transmitting multi-beam formation circuit 1003 forms a plurality of receiving beams simultaneously by carrying out a prescribed weighting with respect to each transmission signal modulated by each modulation unit 1002. This weighting is also executed according to the weighting control device 1011. The amount of weight is set up such that the beam patterns of the transmitting side and the receiving side coincide with each other for the identical radio terminal 20.

[0025] Fig. 5 shows a detailed configuration of the transmitting multi-beam formation circuit 1003 of Fig. 2. The transmission signals outputted from each modulation unit 1002 are entered into a corresponding transmitting beam formation circuit 1017 (1017a, 1017b, 1017c). Each transmitting beam formation circuit 1017 combines the entered transmission signals by weighting them according to weights set by the weight control device 1011. Then, each transmitting beam formation circuit 1017 outputs weighted and combined signals to a corresponding frequency converter 1004.

[0026] Fig. 6 shows a detailed configuration of the transmitting beam formation circuit 1017 of Fig. 5. The transmission signals outputted from each modulation unit 1002 are split by a splitter 1019, and each split signal is entered into a corresponding weighting circuit 1018, where the prescribed weighting is carried out.

[0027] Then, as shown in Fig. 2, each one of four beams formed by the transmitting multi-beam formation circuit 1003 is applied with a frequency conversion into the RF band by a corresponding frequency converter 1004, and each frequency converted transmission signal is amplified by a corresponding amplifier (high output amplifier) 1005. Then, the transmission signals are transmitted from the corresponding antenna elements 12 through the switches 1006 to the radio terminal 20.

[0028] In the radio base station 10 of this embodiment, the weight control device 1011 derives an appropriate amount of weight for each radio terminal 20 as described above at a time of carrying out the radio communications with respect to the radio terminals 20 of Fig. 1. Then, the derived amount of weight for each radio terminal 20 is stored into the memory unit 1013 of Fig. 2 in correspondence to an identifier of that radio terminal 20. The weight control device 1011 can read out the appropriate amount of weight for each radio terminal 20 from the memory unit 1013 whenever necessary.

[0029] The MAC unit 1001 is connected with each modulation unit 1002 and each demodulation unit 1010, and constructs frames corresponding to each modulation unit 1002 and each demodulation unit 1010.

[0030] In the case of TDMA/TDD (Time Division Multiple Access/Time Division Duplex) scheme, one frame is constructed for a pair of the modulation unit 1002a and the demodulation unit 1010a, for example. Similarly, one frame is constructed for a pair of the modulation unit 1002b and the demodulation unit 1010b, and one frame is constructed for a pair of the modulation unit 1002c and the demodulation unit 1010c. In this embodiment, a pair of the modulation unit and the demodulation unit are regarded as one modulation/demodulation unit.

[0031] In the case of TDMA/FDD (Time Division Multiple Access/Frequency Division Duplex) scheme, one transmission frame is constructed for the modulation unit 1002a while one reception frame is constructed for the demodulation unit 1010a, and the communications (transmission and reception) are carried out by using these transmission frame and the reception frame as a pair. Similarly, one transmission frame is constructed for the modulation unit 1002b or 1002c while one reception frame is constructed for the demodulation unit 1010b or 1010c, and the communications are carried out by using these transmission frame and the reception frame as a pair. In this embodiment, the modulation unit and the demodulation unit whose transmission frame and reception frame forms a pair are regarded as one modulation/demodulation unit.

[0032] The weight control device 1011 provided in association with the MAC unit 1001 derives an appropriate amount of weight for each radio terminal 20 of Fig. 1 such that the optimum beam pattern for each radio terminal 20 will be formed. This weight control device 1011 can be provided with a function for measuring intensities or signal waveforms of the received signals at each antenna element 12, for example, such that the antenna beam formation at the receiving side can be carried out adaptively. For this antenna beam formation, only those antenna elements 12 with high received signal intensities can be selected so as not to transmit unnecessary radio signals (interference signals) received by the other antenna elements 12, or it is possible to derive the weights for enabling the simultaneous formation of a plurality of beams such that a main beam of an array antenna is set in a direction from which the desired signals are arriving while a null point of the directivity is set in a direction from which the interference signals are arriving, by using an adaptive control algorithm according to the received signals, for example.

[0033] When the location information of the radio terminal 20 can be acquired, it is also possible to derive the optimum amount of weight by utilizing that location information. Of course, the present invention is not limited to any specific method for deriving the amount of weight.

[0034] In this embodiment, the optimum weight for each radio terminal 20 that is derived by a prescribed method is maintained in the memory unit 1013 for each radio terminal 20, in correspondence to an identifier of each radio terminal 20. Then, at a time of carrying out the radio communications with one radio terminal 20, the weight corresponding to the identifier of that radio terminal 20 is read out from the memory unit 1013, and the read out weight is set into the transmitting multi-beam formation circuit 1003 and the receiving multi-beam formation circuit 1009.

[0035] Next, a frame configuration to be used in the radio communication system according to this embodiment will be described. The scheduling processing unit 1012 of the radio base station 10 carries out an allocation of a radio bandwidth with respect to each radio terminal 20 and constructs frames for each modulation/demodulation unit by utilizing the above described weight for each radio terminal 20. Here, the exemplary case of using TDMA/TDD frames will be described for the sake of explanation. Of course, the present invention is not limited to this case of using TDMA/TDD frames.

[0036] Fig. 7 shows a configuration of a general TDMA/TDD frame. This TDMA/TDD frame is an exemplary basic frame configuration in the case of using one modulation/demodulation unit, which comprises a broadcast channel, a communication channel, and a random access channel as shown in Fig. 7.

[0037] The broadcast channel is a channel for notifying control information such as an identifier of the radio base station 10 and a constituent elements of this frame (bandwidth allocation notice). In the following, in particular, a channel for communicating control information such as an identifier will be referred to as BCH (Broadcast Channel), while a channel for communicating frame constituent elements will be referred to as FCH (Frame Channel). Also, the communication channel is a channel for carrying out communications between the radio base station 10 and the radio terminal 20. The random access channel is a channel to be utilized random accesses such as that at a time of the start of communications. Note that, in the frame configuration of Fig. 7, the broadcast channel (BCH, FCH), the communication channel and the random access channel are arranged in this order, but the order among channels is not necessarily limited to this specific case.

[0038] The frame configuration of Fig. 7 is for the case of using one modulation/demodulation unit, and the frame configuration for the case of using a plurality of modulation/demodulation units is also basically similar to that shown in Fig. 7, except that the frame configuration is slightly different depending on whether BCH and FCH are to be handled as a single broadcast channel (which will be referred to as "ONE-FCH" hereafter) or separate channels (which will be referred to as "PLURAL-FCH" hereafter). In the following, the case of transmitting BCH and FCH as a single information as shown in a part (a) of Fig. 8 and the case of transmitting BCH and FCH as separate information as shown in a part (b) of Fig. 8 will be described.

(ONE-FCH)

[0039] In the case of ONE-FCH, the radio base station 10 needs to notify the frame configuration corresponding to all the modulation units and demodulation units to each radio terminal 20 by a single FCH. To this end, the radio base station 10 needs to modulate both FCH and BCH by the same modulation unit and transmit them without any directivity to all the radio terminals 20 within the service area 18 by using the antenna device 14 with no directivity.

[0040] Fig. 9 shows the frame configuration in the case of ONE-FCH. Fig. 9 is directed to the case of using three modulation units 1002 and three demodulation units 1010 as shown in Fig. 2, where the transmission and reception processing is carried out by handling the modulation unit 1002a and the modulation unit 1010a in pair, the modulation unit 1002b and the demodulation unit 1010b in pair, and the modulation unit 1002c and the demodulation unit 1010c in pair. Here, it is assumed that the frame formed by the modulation unit 1002a and the demodulation unit 1010a is "frame #1", the modulation unit 1002b and the demodulation unit 1010b is "frame #2", and the modulation unit 1002c and the demodulation unit 1010c is "frame #3",

[0041] In the case of the frame configuration of Fig. 9, the frame configuration for the frames #1, #2 and #3 will be notified to each radio terminal 20 by a single FCH. In the case of transmission without any directivity at the antenna device 14, one of a plurality of the modulation units 1002 is selected. This selection may be made by providing a modulation/demodulation unit selection unit 1020 in the MAC unit 1001 as shown in Fig. 10, for example. Namely, it is possible to use a configuration in which the transmission is realized by selecting one of a plurality of the modulation units 1002 by this modulation/demodulation unit selection unit 1020 and carrying out the modulation processing by the selected modulation unit 1002. Similarly, in the case of reception without any directivity at the antenna device 14, the reception is realized by selecting one of a plurality of the demodulation units 1010 by this modulation/demodulation unit selection unit 1020 and carrying out the demodulation processing by the selected demodulation unit 1010.

[0042] Here, the modulation/demodulation unit selection unit 1020 may be configured to select one modulation unit 1002 and one demodulation unit 1010 for each frame, or select the predetermined modulation unit 1002 and demodulation unit 1010 in the case of transmission and reception without any directivity.

(PLURAL-FCH)

[0043] In the case of PLURAL-FCH, the radio base station 10 first transmits BCH without any directivity to all the radio terminals 20 simultaneously by using the antenna with no directivity. Then, FCHs of the respective frames are modulated by utilizing the respectively corresponding modulation units 1002, and transmitted to the respectively corresponding radio terminals 20 simultaneously by using the antennas with the antenna directivities suitable for the respective FCHs.

[0044] Fig. 11 shows the frame configuration in the case of PLURAL-FCH. Fig. 11 is also directed to the case of using three modulation units 1002 and three demodulation units 1010 as shown in Fig. 2, where the transmission and reception processing is carried out by handling the modulation unit 1002a and the modulation unit 1010a in pair, the modulation unit 1002b and the demodulation unit 1010b in pair, and the modulation unit 1002c and the demodulation unit 1010c in pair. Here, it is also assumed that the frame formed by the modulation unit 1002a and the demodulation unit 1010a is "frame #1", the modulation unit 1002b and the demodulation unit 1010b is "frame #2", and the modulation unit 1002c and the demodulation unit 1010c is "frame #3",

[0045] In the case of the frame configuration of Fig. 11, one FCH (FCH1) to be transmitted after being modulated at the modulation unit 1002a will notify the frame configuration for the frame #1, one FCH (FCH2) to be transmitted after being modulated at the modulation unit 1002b will notify the frame configuration for the frame #2, and one FCH (FCH3) to be transmitted after being modulated at the modulation unit 1002c will notify the frame configuration for the frame #3.

[0046] Next, the features of the above described ONE-FCH and PLURAL-FCH will be described. In the case of ONE-FCH, the frame configuration for the frames #1, #2 and #3 formed by all the pairs of the modulation units 1002 and the modulation unit 1010 will be notified by using a single FCH. For this reason, FCH becomes a relatively long and it becomes impossible to increase the communication bandwidth for the communication channel any further. On the other hand, in the case of PLURAL-FCH, FCH will be transmitted for each frame, so that FCH can be relatively short and the communication bandwidth for the communication channel can be increased as much. However, in this case, there is a need to carry out the transmission such that there is no mutual interferences among FCH1, FCH2 and FCH3.

[0047] These facts implies the following from a viewpoint of the scheduling algorithm for the communication channels of the frames #1, #2 and #3. Namely, in the case of ONE-FCH, the frame configuration for all the frames #1, #2 and #3 will be notified to each radio terminal 20 simultaneously by a single FCH. For this reason, there is no need to account for the interferences among FCH1, FCH2 and FCH3 unlike the case of PLURAL-FCH. Consequently, it suffices for the scheduling of the communication channels to be such a scheduling that there is no mutual interferences among signals (packets A, B and C) of the communication channels of the frames #1, #2 and #3 that are to be transmitted or received at the identical timing, as shown in Fig. 12A. There is no need to account for the interferences among signals (packets B and D, packets C and D) of the communication channels of the frames #1, #2 and #3 that are to be transmitted or received at different timings.

[0048] In contrast, in the case of PLURAL-FCH, there is a need to realize a scheduling such that there is no mutual interferences among all the signals to be transmitted or received by the communication channels of the frames #1, #2 and #3.. The reason for this is as follows. Namely, in the case of PLURAL-FCH, FCH1, FCH2 or FCH3 for notifying the frame constituent elements of the frame #1, #2 or #3 will be notified only to the radio terminal 20 corresponding to the frame #1, #2, or #3. In other words, there is a need to transmit FCH1 only to the radio terminal 20 (radio terminal group #1) that is scheduled to carry out transmission or reception by using the frame #1, FCH2 only to the radio terminal 20 (radio terminal group #2) that is scheduled to carry out transmission or reception by using the frame #2, and FCH3 only to the radio terminal 20 (radio terminal group #3) that is scheduled to carry out transmission or reception by using the frame #3. Consequently, the antenna directivity is set toward the radio terminal group #1 at a time of transmitting FCH1, toward the radio terminal group #2 at a time of transmitting FCH2, and toward the radio terminal group #3 at a time of transmitting FCH3.

[0049] Here, these FCH1, FCH2 and FCH3 are transmitted to the respective radio terminal groups at the same timing immediately after BCH that is transmitted to all the radio terminals simultaneously, as shown in Fig. 12B, and for this reason there is a need to avoid the mutual interferences among FCH1, FCH2 and FCH3. Consequently, there is also a need for such a scheduling that there is no mutual interferences even among all the signals to be transmitted or received by the communication channel of the frame #1, all the signals to be transmitted or received by the communication channel of the frame #2, and all the signals to be transmitted or received by the communication channel of the frame #3, which are to be transmitted or received after FCH1, FCH2 and FCH3.

[0050] Next, the frame configuration scheduling method to be used in the radio communication system according to this embodiment will be described. In the following, the frame configuration scheduling method will be described for the case of adopting ONE-FCH and for the case of adopting PLURAL-FCH separately. Here, for the sake of simplifying the description, it is assumed that there are three modulation units 1002 and three demodulation units 1010 as shown in Fig. 2.

(A) Case of ONE-FCH

[0051] Fig. 13 shows a processing procedure of the first frame configuration scheduling method in the case of adopting ONE-FCH.

[0052] First, at the step S101 of Fig. 13, the allocation of the communication bandwidths with respect to the frames #1, #2 and #3 is carried out.

[0053] The scheduling processing unit 1012 of Fig. 2 selects one radio terminal 20a (which will be referred to as "Ma" hereafter) that requires the largest communication bandwidth in the downlink (the radio base station 10 → the radio terminal 20) among the plurality of radio terminals 20 located within the service area 18 of Fig. 1. Then, the weight for the selected radio terminal Ma (which will be referred to as "Ga" hereafter) is extracted from the memory unit 1013 of Fig. 2. Here, the communication bandwidth required by the radio terminal Ma will be referred to as "Ba", Note that the "communication bandwidth" implies the bandwidth necessary in the radio channel. Thus the communication bandwidth can vary depending on the modulation scheme, the error correction scheme, the physical preamble, etc. to be applied.

[0054] Next, the scheduling processing unit 1012 selects those weights that do not interfere with the weight Ga of the selected radio terminal Ma from the memory unit 1013 and selects one radio terminal 20b (which will be referred to as "Mb" hereafter) that requires the largest communication bandwidth among the radio terminals with the selected weights. Here, the weight of the radio terminal Mb will be referred to as "Gb", and the communication bandwidth required by the radio terminal Mb will be referred to as "Bb".

[0055] Next, the scheduling processing unit 1012 selects those weights that do not interfere with the weights Ga and Gb of the selected radio terminals Ma and Mb from the memory unit 1013, and selects one radio terminal 20c (which will be referred to as "Mc" hereafter) that requires the largest communication bandwidth among the radio terminals 20 with the selected weights. Here, the weight of the radio terminal Mc will be referred to as "Gc", and the communication bandwidth required by the radio terminal Mc will be referred to as "Bc".

[0056] Among the radio terminals Ma, Mb and Mc selected in this way, the following relationships hold.

(a) The weights Ga, Gb and Gc do not interfere with each other.

(b) The sizes of the communication bandwidths Ba, Bb and Bc are in a relationship of Ba > Bb > Bc.

[0057] Then, as shown in Fig. 14, for example, the radio base station 10 forms three antenna directivity beam patterns 22a. 22b and 22c at the antenna device 14, with respect to the radio terminal Ma with the weight Ga (the radio terminal 20a), the radio terminal Mb with the weight Gb (the radio terminal 20b), and the radio terminal Mc with the weight Gc (the radio terminal 20c), respectively.

[0058] In the following, it is assumed that the frame #1 shown in Fig. 12A is set as a reference frame at a time of carrying out the frame configuration scheduling. In this case, as shown in Fig. 15A, the scheduling processing unit 1012 allocates the communication bandwidth of the frame #1 to the radio terminal Ma with the largest required communication bandwidth, the communication bandwidth of the frame #2 to the radio terminal Mb with the next largest required communication bandwidth, and the communication bandwidth of the frame #3 to the radio terminal Mc with the smallest required communication bandwidth, for example. Then, all the communication bandwidths allocated to the radio terminals Ma, Mb and Mc are scheduled to start immediately after the notification of FCH.

[0059] Next, at the step S102 of Fig. 13, the scheduling processing unit 1012 calculates differences among the communication bandwidths Ba, Bb and Bc allocated to the frames #1, #2 and #3. More specifically, the scheduling processing unit 1012 calculates a difference between the communication bandwidth Ba allocated to the frame #1 that is the reference frame and the communication bandwidth Bb allocated to the frame #2, as well as a difference between the communication bandwidth Ba and the communication bandwidth Bc allocated to the frame #3.

[0060] Next, at the step S103 of Fig. 13, the scheduling processing unit 1012 compares each communication bandwidth difference calculated at the above step S102 with a prescribed value (threshold) that is set up in advance. When all the differences are less than or equal to the threshold (step S103 NO), all the communication bandwidths Ba, Bb and Bc are regarded as the same, while the largest communication bandwidth is set as a representative value of the three communication bandwidths Ba, Bb and Bc. This representative value will be subsequently utilized as a value common to these communication bandwidths that are regarded as the same.

[0061] Then, the processing returns to the step S101, and the steps S101 to S103 are executed similarly with respect to the radio terminals 20 within the service area 18 other than the radio terminals Ma, Mb and Mc, as shown in Fig. 15B. Here, however, the step S101 in the second and subsequent rounds allocates the communication bandwidth after the representative value of a total sum of the communication bandwidths allocated up to this point, rather than immediately after the notification of FCHs for the frames #1, #2 and #3.

[0062] On the other hand, when there is any communication bandwidth difference which is greater than the threshold (step S103 YES), the processing proceeds to the step S104.

[0063] At the step S104 of Fig. 13, if a difference between the communication bandwidth Ba and the communication bandwidth Bb is less than the threshold but a difference between the communication bandwidth Ba and the communication bandwidth Bc is greater than the threshold, for example, the scheduling processing unit 1012 regards the communication bandwidth Ba and the communication bandwidth Bb as the same, while the larger communication bandwidth is set as the representative value.

[0064] On the other hand, the scheduling processing unit 1012 carries out the allocation of the communication bandwidth subsequent to the communication bandwidth Bc with respect to the frame #3. The scheduling processing unit 1012 selects those weights that do not interfere with the weights Ga and Gb of the radio terminals Ma and Mb that are already allocated to the frames #1 and #2 other than the frame #3 from the memory unit 1013. Then, the scheduling processing unit 1012 selects one radio terminal 20 (which will be referred to as "Md" hereafter) that requires the largest communication bandwidth among those radio terminals 20 that satisfy a condition (which will be referred to as "condition A" hereafter) that the required communication bandwidth is less than or equal to the difference between the communication bandwidth Ba and the communication bandwidth Bc. Here, the weight of the radio terminal Md will be referred to as "Gd", and the communication bandwidth required by the radio terminal Md will be referred to as "Bd".

[0065] Then, the communication bandwidth Bd is allocated after the communication bandwidth Bc in the frame #3 with respect to the radio terminal Md, as shown in Fig. 15C.

[0066] At the step S105 of Fig. 13, if the allocation of the communication bandwidths with respect to all the radio terminals 20 located within the service area 18 of Fig. 1 is finished (step S105 YES), the allocation of the communication bandwidth in the downlink is finished. The allocation of the communication bandwidth in the downlink is also similarly finished when the remaining communication bandwidth for the downlink in the frames #1, #2 and #3 is not greater than a prescribed value (step S105 YES).

[0067] On the other hand, if there is a radio terminal 20 to which the communication bandwidth is not allocated yet and the remaining communication bandwidth for the downlink is greater than the prescribed value (step S105 NO), the processing returns to the step S102. Then, the scheduling processing unit 1012 calculates a difference between the communication bandwidth Ba and a total sum Bc+Bd of the communication bandwidths Bc and Bd this time, and compares this difference with the threshold at the step S103.

[0068] After the allocation to the downlink is carried out in this way, the remaining communication bandwidth will be allocated to the uplink (the radio terminal 20 → the radio base station 10). In the case of the TDMA/TDD scheme, it is possible to carry out the transmission processing using one frame while the reception processing is carried out using another frame, and this causes no problem as long as there is no mutual interference so that the above described algorithm is applicable. In other words, the allocation to the uplink can be carried out similarly as the allocation to the downlink, so that the detailed description of the allocation to the uplink will be omitted here. Of course, it is not absolutely necessary to allocate the communication bandwidths for the uplink after the communication bandwidths are allocated to the downlink.

[0069] Next, the second frame configuration scheduling method in the case of adopting ONE-FCH will be described. Fig. 16 shows a processing procedure of the second frame configuration scheduling method in the case of adopting ONE-FCH. In the first scheduling method shown in Fig. 13, the limitation given by the condition A (that the required communication bandwidth is less than the difference between the communication bandwidth Ba and the communication bandwidth Bc) is applied at a time of selecting a weight to be allocated next at the step S104, it is also possible to remove this limitation. This second scheduling method is an example in which the limitation given by the condition A is removed.

[0070] The steps S201 to S203 of Fig. 16 are similar to the steps S101 to S103 of Fig. 13 so that their description will be omitted here.

[0071] At the step S204 of Fig. 16, if a difference between the communication bandwidth Ba and the communication bandwidth Bb is less than the threshold but a difference between the communication bandwidth Ba and the communication bandwidth Bc is greater than the threshold, for example, the scheduling processing unit 1012 regards the communication bandwidth Ba and the communication bandwidth Bb as the same, while the larger communication bandwidth is set as the representative value.

[0072] On the other hand, the scheduling processing unit 1012 carries out the allocation of the communication bandwidth subsequent to the communication bandwidth Bc with respect to the frame #3. The scheduling processing unit 1012 selects those weights that do not interfere with the weights Ga and Gb of the radio terminals Ma and Mb that are already allocated to the frames #1 and #2 other than the frame #3 from the memory unit 1013. Then, the scheduling processing unit 1012 selects one radio terminal 20 (which will be referred to as "Me" hereafter) that requires the largest communication bandwidth among the radio terminals 20 with the selected weights. Here, the weight of the radio terminal Me will be referred to as "Ge", and the communication bandwidth required by the radio terminal Me will be referred to as "Be".

[0073] Then, the communication bandwidth Be is allocated after the communication bandwidth Bc in the frame #3 with respect to the radio terminal Me, as shown in Fig. 17A.

[0074] At the step S205 of Fig. 16, if the allocation of the communication bandwidths with respect to all the radio terminals 20 located within the service area 18 of Fig. 1 is finished (step S205 YES), the allocation of the communication bandwidth in the downlink is finished. The allocation of the communication bandwidth in the downlink is also similarly finished when the remaining communication bandwidth for the downlink in the frames #1, #2 and #3 is not greater than a prescribed value (step S205 YES).

[0075] On the other hand, if there is a radio terminal 20 to which the communication bandwidth is not allocated yet and the remaining communication bandwidth for the downlink is greater than the prescribed value (step S205 NO), the processing returns to the step S202. Then, the scheduling processing unit 1012 calculates a difference between the communication bandwidth Ba and a total sum Bc+Be of the communication bandwidths Bc and Be this time, and compares this difference with the threshold at the step S203. Then, if this difference is less than or equal to the threshold (step S203 NO), the scheduling processing unit 1012 regards the communication bandwidth Ba and the communication bandwidth Bc+Be are the same, and the processing returns to the step S201, while the larger communication bandwidth among the communication bandwidth Ba and the communication bandwidth Bc+Be is set as a representative value.

[0076] On the other hand, when that difference is greater than the threshold (step S203 YES), the processing proceeds to the step S204. Here, if the communication bandwidth Ba < the communication bandwidth Bc+Be, the scheduling processing unit 1012 selects those weights that do not interfere with the weight Ge from the memory unit 1013, and selects one radio terminal 20 (which will be referred to as "Mf" hereafter) that requires the largest communication bandwidth among the radio terminals 20 with the selected weights. Here, the weight of the radio terminal Mf will be referred to as "Gf", and the communication bandwidth required by the radio terminal Mf will be referred to as "Bf". Note here that the interference from the radio terminal Mc (the weight Gc) is not accounted at a time of selecting the radio terminal Mf because the communication bandwidth Ba > the communication bandwidth Bc.

[0077] Then, the communication bandwidth Bf is allocated after the communication bandwidth Ba in the frame #1 with respect to the radio terminal Mf, as shown in Fig. 17A. It is also possible to allocate the communication bandwidth Bf after the communication bandwidth Bb in the frame #2 instead.

[0078] As described, the second scheduling method is a method for carrying out the allocation of the communication bandwidths sequentially from the frame for which the total sum of the allocated communication bandwidths becomes smallest. In contrast, the first scheduling method described above is a method for carrying out the allocation of the communication bandwidths by using the reference frame (which is the frame #1 here) such that the total sum of the communication bandwidths allocated to the frames other than the frame #1 always becomes less than or equal to the total sum of the communication bandwidths allocated to the frame #1.

[0079] Note that, at the steps S101, S104, S201 and S204 of the first and second scheduling methods described above, if there is no radio terminal 20 that does not interfere, the allocation of the communication bandwidths will be interrupted. For example, as shown in Fig. 17B, if there is no radio terminal 20 that does not interfere with the communication bandwidth Ba allocated to the frame #1, the allocation of the communication bandwidths with respect to the frames #2 and #3 of the same timing is interrupted, and then the allocation will be carried out after the communication bandwidth Ba of the frame #1. Note however that, in this case, the total sum of the communication bandwidths allocated to the frames

#2 and #3 will be regarded as the same as the total sum of the communication bandwidth allocated to the frame #1.

[0080] As far as the random access channel is concerned, basically the antenna device 14 with no directivity will be used and the demodulation processing will be carried out by using the demodulation unit 1010 selected by the modulation/demodulation unit selection unit 1020 of Fig. 10, similarly as in the case of BCH. Note however that it is also possible to use the antenna device 14 with the directivities for dividing the space into three and carry out the demodulation processing by utilizing three demodulation units 1010.

[0081] Note also that the first and second scheduling methods described above are directed to the case of managing the weight and the communication bandwidth for each radio terminal 20, but it is also possible to classify the radio terminals 20 into groups according to their weights. In this case, the scheduling processing unit 1012 regards those radio terminals 20 for which the weight can be regarded as the same, as one group. In this regard, it suffices to consider the radio terminals Ma, Mb and Mc described above as groups of radio terminals with the weights Ga, Gb and Gc respectively.

[0082] As shown in an example of Fig. 18, the radio terminals 20d and 20e can be regarded as a radio terminal group 26 with the same weight. Then, the radio terminal group is scheduled to carry out communications by using the same frame. Also, the consecutive communication bandwidths will be allocated to the radio terminals of the same radio terminal group that carry out the transmission by using the same frame. In this way, there is no need to provide a guard time for the purpose of setting up the weights for the antenna elements 12 so that the frame efficiency can be improved. In other words, it is effective for the effective utilization of the frequencies.

(B) Case of PLURAL-FCH

[0083] Fig. 19 shows a processing procedure of the frame configuration scheduling method in the case of adopting PLURAL-FCH.

[0084] The step S301 of Fig. 19 is similar to the step S101 of Fig. 13 so that its description will be omitted here. It is assumed here that a radio terminal M1a is allocated to the frame #1, a radio terminal M2a is allocated to the frame #2, and a radio terminal M3a is allocated to the frame #3 as shown in Fig. 20A. Here, the weight of the radio terminal M1a will be referred to as "G1a", and the communication bandwidth required by the radio terminal M1a will be referred to as "B1a". Similarly, the weight of the radio terminal M2a will be referred to as "G2a", and the communication bandwidth required by the radio terminal M2a will be referred to as "B2a", while the weight of the radio terminal M3a will be referred to as "G3a", and the communication bandwidth required by the radio terminal M3a will be referred to as "B3a".

[0085] Next, at the step S302 of Fig. 19, the scheduling processing unit 1012 calculates a total sum of the communication bandwidths allocated to each of the frames #1, #2 and #3.

[0086] Next, at the step S303 of Fig. 19, the scheduling processing unit 1012 carries out the scheduling with respect to the frame for which the total sum of the communication bandwidths calculated at the step S302 is the smallest among the frames #1, #2 and #3. For example, if the total sum of the bandwidths allocated to the frame #3 is the smallest as shown in an example of Fig. 20A, the scheduling processing unit 1012 selects those weights that do not interfere with the weights (G1a and G2a here) of the radio terminals 20 that are already allocated to the frames #1 and #2 other than the frame #3 from the memory unit 1013. Then, the scheduling processing unit 1012 selects one radio terminal 20 (which will be referred to as "M3b" hereafter) that requires the largest communication bandwidth among those radio terminals 20 with the selected weights. Here, the weight of the radio terminal M3b will be referred to as "G3b", and the communication bandwidth required by the radio terminal M3b will be referred to as "B3b".

[0087] Then, the communication bandwidth B3b is allocated after the communication bandwidth B3a in the frame #3 with respect to the radio terminal M3b, as shown in Fig. 20B.

[0088] At the step S304 of Fig. 19, if the allocation of the communication bandwidths with respect to all the radio terminals 20 located within the service area 18 of Fig. 1 is finished (step S304 YES), the allocation of the communication bandwidth in the downlink is finished. The allocation of the communication bandwidth in the downlink is also similarly finished when the remaining communication bandwidth for the downlink in the frames #1, #2 and #3 is not greater than a prescribed value (step S304 YES).

[0089] On the other hand, if there is a radio terminal 20 to which the communication bandwidth is not allocated yet and the remaining communication bandwidth for the downlink is greater than the prescribed value (step S304 NO), the processing returns to the step S302. Then, the allocation of the communication bandwidths with respect to each of the frames #1, #2 and #3 is carried out by repeating the steps S302 to S304. Note that, at the step S302, if there is no radio terminal 20 that does not interfere, the allocation of the communication bandwidths with respect to that frame will be interrupted, and the allocation of the communication bandwidths with respect to another frame will be carried out.

[0090] After the allocation to the downlink is carried out in this way, the remaining communication bandwidth will be allocated to the uplink. In the case of the TDMA/TDD scheme, similarly as in the case of ONE-FCH, it is possible to carry out the transmission processing using one frame while the reception processing is carried out using another frame, and this causes no problem as long as there is no mutual interference so that the above described algorithm is applicable. In other words, the allocation to the uplink can be carried out similarly as the allocation to the downlink, so that the detailed description of the allocation to the uplink will be omitted here. Of course, it is not absolutely necessary to allocate the communication bandwidths for the uplink after the communication bandwidths are allocated to the downlink.

[0091] Also, in the case of grouping the radio terminals 20 according to their weights, the scheduling similar to the above described will be carried out by considering the radio terminals M1a, M2a, M3a and M3b described above as groups of radio terminals with the weights G1a, G2a, G3a and G3b respectively.

[0092] It is to be noted that the above description is directed to the case of using the TDMA/TDD frame as the frame configuration, but the present invention is not limited to this case and it is also applicable to the case of using the TDMA/FDD scheme. In the case of the TDMA/FDD frame, different frequencies will be used for the transmission and the reception so that the scheduling is carried out totally independently for the transmission and the reception, but the scheduling method similar to the above described embodiment can be used basically. Note that in this case the switches 1006 in Fig. 2 should be replaced by duplexers, and the method for deriving the weights for the purpose of the beam formation (for the transmission) will be changed.

[0093] As described, according to the present invention, it becomes possible for the radio base station to realize the radio communications with different radio terminals at the same time using the same frequency, so that it is possible to increase the number of radio terminals that can be accommodated by the radio base station.

[0094] Also, it is possible to suppress the interferences by controlling the directivity of the antenna so that it is possible to improve the communication quality. It is also possible to shorten the switching time necessary for the antenna control by allocating the consecutive communication bandwidths in the same frame with respect to the radio terminals for which the antenna directivity is similar. In addition, it is also possible to allocate the communication bandwidths efficiently so that the frequency utilization efficiency can be improved.

[0095] In other words, in the present invention, a plurality of time division multiplexed frames are transmitted through a plurality of space dividing beams such that it becomes possible for the radio base station to realize the radio communications with different radio terminals at the same time using the same frequency, and therefore it is possible to increase the number of radio terminals that can be accommodated by the radio base station.

[0096] It is to be noted that a part of the above described embodiment according to the present invention may be conveniently implemented using a conventional general purpose digital computer programmed according to the teachings of the present specification, as will be apparent to those skilled in the computer art. Appropriate software coding can readily be prepared by skilled programmers based on the teachings of the present disclosure, as will be apparent to those skilled in the software art.

[0097] In particular, the scheduling processing unit in the above described embodiment can be conveniently implemented in a form of a software package.

[0098] Such a software package can be a computer program product which employs a storage medium including stored computer code which is used to program a computer to perform the disclosed function and process of the present invention. The storage medium may include, but is not limited to, any type of conventional floppy disks, optical disks, CD-ROMs, magneto-optical disks, ROMs, RAMs, EPROMs, EEPROMs, magnetic or optical cards, or any other suitable media for storing electronic instructions.

[0099] It is also to be noted that, in the embodiments described above, "no mutual interference" does not necessarily implies absolutely zero interference and should be construed as meaning "substantially no mutual interference", i.e., the amount of interference is less than a prescribed threshold.

[0100] It is also to be noted that, besides those already mentioned above, many modifications and variations of the above embodiment may be made without departing from the novel and advantageous features of the present invention. Accordingly, all such modifications and variations are intended to be included within the scope of the appended claims.

Claims

1. A radio base station (10) for transferring signals of time division multiplexed frames with respect to a plurality of radio terminals (20), the radio base station comprising:

a beam formation unit (1003) configured to form a plurality of space dividing beams simultaneously;
a plurality of antenna elements (12) configured to transfer the signals with respect to the radio terminals (20) by transmitting the plurality of space dividing beams towards the radio terminals (20);
a scheduling processing unit (1012) configured to allocate communication bandwidths to the radio terminals (20) such that there is substantially no mutual interference among those signals to be transferred by different frames, with respect to a plurality of frames that are corresponding to at least one of the plurality of space dividing beams,
a memory unit (1013) configured to store weights respectively corresponding to the radio terminals, that are to be used in forming the plurality of space dividing beams, and
a weight control unit (1011) configured to set the

weights to the beam formation unit,

wherein the scheduling processing (1012) unit is configured to allocate communication bandwidths of an identical time in different frames to different radio terminals (20) such that there is substantially no mutual interference among those signals to be transferred at the identical time with respect to the different radio terminals (20) according to the weights corresponding to the different radio terminals (20) as stored in the memory unit, and is then configured to allocate entire frame configuration information indicating frame configurations of all the time division multiplexed frames to one of the time division multiplexed frames.

2. The radio base station (10) of claim 1, wherein the scheduling processing unit (1012) is configured to schedule such that the entire frame configuration information is notified to all the radio terminals (20) simultaneously.

3. A radio base station (10) for transferring signals of time division multiplexed frames with respect to a plurality of radio terminals (20), the radio base station (10) comprising:

a beam formation unit (1003) configured to form a plurality of space dividing beams simultaneously;
a plurality of antenna elements (12) configured to transfer the signals with respect to the radio terminals (20) by transmitting the plurality of space dividing beams toward the radio terminals (20); and
a scheduling processing unit (1012) configured to allocate communication bandwidths to the radio terminals (20) such that there is substantially no mutual interference among those signals to be transferred by different frames, with respect to a ' plurality of frames that are corresponding to at least one of the plurality of space dividing beams,
a memory unit (1013) configured to store weights respectively corresponding to the radio terminals, that are to be used in forming the plurality of space dividing beams and
a weight control unit (1011) configured to set the weights to the beam formation unit (1003),

wherein the scheduling processing unit (1012) is configured to allocate communication bandwidths in different frames to different radio terminals (20) such that there is substantially no mutual interference among those signals to be transferred with respect to the different radio terminals (20) according to the weights corresponding to the different radio terminals as stored in the memory unit, and allocates a next communication bandwidth to a frame for which a total sum of allocated communication bandwidths is the smallest among the time division multiplexed frames; and
wherein the scheduling processing unit (1012) is configured to allocate a plurality of frame configuration information each indicating a frame configuration of a respective time division multiplexed frame, to corresponding ones of the time division multiplexed frames respectively.

4. The radio base station of claim 3, wherein the scheduling processing unit (1012) - is configured to schedule such that the plurality of frame configuration information are notified to all the radio terminals (20) simultaneously.

5. The radio base station of either of claims 1 or 3, wherein the scheduling processing unit (1012) is configured to handle a group of radio terminals with similar weights as an identical radio terminal.

6. The radio base station of either of claims 1 or 3, wherein the beam formation unit (1003) has a multibeam formation circuit configured to form the plurality of space dividing beams simultaneously by weighting the signals to be transmitted or received by the antenna elements (12) using the weights set by the weight control unit (1011).

7. A frame configuration method for time division multiplexed frames to transfer signals between a radio base station (10) and a plurality of radio terminals (20), the frame configuration method comprising:

(a) allocating communication bandwidths of an identical time in different frames to different radio terminals (20) such that there is substantially no mutual interference among those signals to be transferred at the identical time with respect to the different radio terminals according to weights respectively corresponding to the different radio terminals, that are used in forming a plurality of space dividing beams for transferring the signals between the radio base station and the radio terminals; and
(b) allocating entire frame configuration information indicating frame configurations of all the time division multiplexed frames to one of the time division multiplexed frames.

8. The frame configuration method of claim 7, wherein the step (b) allocates the entire frame configuration information to a frame to which control information to be transmitted to all the radio terminals (20) simultaneously is allocated.

9. The frame configuration method of claim 8, wherein when there is a difference between total sums of the communication bandwidths allocated to the time division multiplexed frames, the step (a) allocates a next communication bandwidth to a frame for which a total sum of allocated communication bandwidth is the smallest among the time division multiplexed frames.

10. The frame configuration method of claim 9, wherein the step (a) determines the next communication bandwidth to be allocated such that a total sum of allocated communication bandwidths for a reference frame selected in advance among the time division multiplexed frames is not exceeded by a total sum of allocated communication bandwidths for any other time division multiplexed frames.

11. The frame configuration method of claim 9, wherein the step (a) compares the difference between the total sums of the communication bandwidths with a prescribed threshold.

12. The frame configuration method of claim 11, wherein when the difference between the total sums of the communication bandwidths is less than or equal to the prescribed threshold, the step (a) regards the total sums of the communication bandwidths as identical.

13. A frame configuration method for time division multiplexed frames to transfer signals between a radio base station (10) and a plurality of radio terminals (20), the frame configuration method comprising:

(a) allocating communication bandwidths in different frames to different radio terminals such that there is substantially no mutual interference among those signals to be transferred with respect to the different radio terminals (20) according to weights respectively corresponding to the different radio terminals (20), that are to be used in forming a plurality of space dividing beams for transferring the signals between the radio base station and the radio terminals, and allocating a next communication bandwidth to a frame for which a total sum of allocated communication bandwidths is the smallest among the time division multiplexed frames; and

(b) allocating a plurality of frame configuration information each indicating a frame configuration of a respective time division multiplexed frame, to corresponding ones of the time division multiplexed frames respectively.

14. A computer usable medium having computer readable program codes embodied therein for causing a computer to function as a scheduling processing unit in a radio base station (10) for transferring signals of time division multiplexed frames with respect to a plurality of radio terminals (20), the computer readable program codes include:

a first computer readable program code for causing said computer to allocate entire frame configuration information indicating frame configurations of all the time division multiplexed frames to one of the time division multiplexed frames, or allocate a plurality of frame configuration information each indicating a frame configuration of a respective time division multiplexed frame, to corresponding ones of the time division multiplexed frames respectively; and

a second computer readable program code for causing said computer to allocate communication bandwidths of an identical time in different frames to different radio terminals such that there is substantially no mutual interference among those signals to be transferred at the identical time with respect to the different radio terminals according to weights respectively corresponding to the different radio terminals, that are to be used in forming a plurality of space dividing beams for transferring the signals between the radio base station (10) and the radio terminals (20), or allocate communication bandwidths in different frames to different radio terminals (20) such that there is substantially no mutual interference among those signals to be transferred with respect to the different radio terminals according to weights respectively corresponding to the different radio terminals, that are to be used in forming a plurality of space dividing beams for transferring the signals between the radio base station and the radio terminals and allocate a next communication bandwidth to a frame for which a total sum of allocated communication bandwidth is the smallest among the time division multiplexed frames.

15. A carrier medium carrying computer readable instructions for controlling the computer to carry out the method of any one claims 7 to 13.

Patentansprüche

1. Funkbasisstation (10) zum Übertragen von Signalen von Zeitmultiplexrahmen bezüglich einer Vielzahl von Funkendgeräten (20), wobei die Funkbasisstation umfasst:

eine Keulenformungseinheit (1003), die zum gleichzeitigen Formen einer Vielzahl von Raumvielfachkeulen konfiguriert ist;

eine Vielzahl von Antennenelementen (12), die zum Übertragen der Signale bezüglich der Funkendgeräte (20) durch Übertragen der Vielzahl von Raumvielfachkeulen zu den Funkendgeräten (20) konfiguriert sind;

eine Scheduling-Verarbeitungseinheit (1012), die zum Zuweisen von Kommunikationsbandbreiten an die Funkendgeräte (20) konfiguriert ist, sodass es im Wesentlichen keine gegenseitige Störung unter diesen durch verschiedene Rahmen zu übertragenden Signalen gibt bezüglich einer Vielzahl von Rahmen, die mindestens einem der Vielzahl von Raumvielfachkeulen entsprechen,

eine Speichereinheit (1013), die zum Speichern von den jeweiligen Funkendgeräten entsprechenden Gewichten konfiguriert ist, die zum Formen der Vielzahl von Raumvielfachkeulen zu verwenden sind, und

eine Gewichtsteuereinheit (1011), die zum Setzen der Gewichte für die Keulenformungseinheit konfiguriert ist,

worin die Scheduling-Verarbeitungseinheit (1012) dazu konfiguriert ist, Kommunikationsbandbreiten einer identischen Zeit in verschiedenen Rahmen verschiedenen Funkendgeräten (20) zuzuweisen, sodass es im Wesentlichen keine gegenseitige Störung unter diesen Signalen gibt, die zur identischen Zeit bezüglich der verschiedenen Funkendgeräte (20) gemäß den Gewichten zu übertragen sind, die den verschiedenen Funkendgeräten (20) entsprechen, wie in der Speichereinheit gespeichert ist, und dann dazu konfiguriert ist, die gesamte Rahmenkonfigurationsinformation, die Rahmenkonfigurationen aller Zeitmultiplexrahmen anzeigt, einem der Zeitmultiplexrahmen zuzuweisen.

2. Funkbasisstation (10) nach Anspruch 1, worin die Scheduling-Verarbeitungseinheit (1012) dazu konfiguriert ist, das Scheduling so auszuführen, dass die gesamte Rahmenkonfigurationsinformation allen Funkendgeräten (20) gleichzeitig gemeldet wird.

3. Funkbasisstation (10) zum Übertragen von Signalen von Zeitmultiplexrahmen bezüglich einer Vielzahl von Funkendgeräten (20), wobei die Funkbasisstation (10) umfasst:

eine Keulenformungseinheit (1003), die zum gleichzeitigen Formen einer Vielzahl von Raumvielfachkeulen konfiguriert ist;

eine Vielzahl von Antennenelementen (12), die zum Übertragen der Signale bezüglich der Funkendgeräte (20) durch Übertragen der Vielzahl von Raumvielfachkeulen zu den Funkendgeräte (20) konfiguriert sind; und

eine Scheduling-Verarbeitungseinheit (1012), die zum Zuweisen von Kommunikationsbandbreiten an die Funkendgeräte (20) konfiguriert ist, sodass es im Wesentlichen keine gegenseitige Störung unter diesen durch verschiedene Rahmen zu übertragenden Signalen gibt bezüglich einer Vielzahl von Rahmen, die mindestens einem der Vielzahl von Raumvielfachkeulen entsprechen,

eine Speichereinheit (1013), die zum Speichern von den jeweiligen Funkendgeräten entsprechenden Gewichten konfiguriert ist, die zum Formen der Vielzahl von Raumvielfachkeulen zu verwenden sind, und

eine Gewichtsteuereinheit (1011), die zum Setzen der Gewichte für die Keulenformungseinheit (1003) konfiguriert ist,

worin die Scheduling-Verarbeitungseinheit (1012) dazu konfiguriert ist, Kommunikationsbandbreiten in verschiedenen Rahmen verschiedenen Funkendgeräten (20) zuzuweisen, sodass es im Wesentlichen keine gegenseitige Störung unter diesen Signalen gibt, die bezüglich der verschiedenen Funkendgeräte (20) gemäß den Gewichten zu übertragen sind, die den verschiedenen Funkendgeräten entsprechen, wie in der Speichereinheit gespeichert ist, und eine nächste Kommunikationsbandbreite einem Rahmen zuweist, für den eine Gesamtsumme von zugewiesenen Kommunikationsbaudbreiten die kleinste unter den Zeitmultiplexrabmen ist; und
worin die Scheduling-Verarbeitungseinheit (1012) dazu konfiguriert ist, eine Vielzahl von Rahmenkonfigurationsinformationen, deren jede eine Rahmenkonfiguration eines jeweiligen Zeitmultiplexrahmens anzeigt, entsprechenden der jeweiligen Zeitmultiplexrahmen zuzuweisen.

4. Funkbasisstation nach Anspruch 3, worin die Scheduling-Verarbeitungseinheit (1012) dazu konfiguriert ist, das Scheduling so auszuführen, dass die Vielzahl von Rahmenkonfigurationsinformationen allen Funkendgeräten (20) gleichzeitig gemeldet werden.

5. Funkbasisstation nach Anspruch 1 oder 3, worin die Scheduling-Verarbeitungseinheit (1012) dazu konfiguriert ist, eine Gruppe von Funkendgeräten mit ähnlichen Gewichten wie ein identisches Funkendgerät zu behandeln.

6. Funkbasisstation nach Anspruch 1 oder 3, worin die Keulenformungseinheit (1003) eine Mehrfachkeulen-Formungsschaltung hat, die dazu konfiguriert ist, die Vielzahl von Raumvielfachkeulen durch Gewichtung der Signale, die von den Antennenelementen (12) zu übertragen oder zu empfangen sind, unter Verwendung der von der Gewichtsteuereinheit (1011) gesetzten Gewichte gleichzeitig zu formeln.

7. Rahmenkonfigurationsverfahren für Zeitmultiplexrahmen zum Übertragen von Signalen zwischen einer Funkbasisstation (10) und einer Vielzahl von Funkendgeräten (20), wobei das Rahmenkonfigurationsverfahren umfasst:

(a) Zuweisen von Kommunikationsbandbreiten einer identischen Zeit in verschiedenen Rahmen an verschiedene Funkendgeräte (20), sodass es im Wesentlichen keine gegenseitige Störung unter diesen Signalen gibt, die zur identischen Zeit bezüglich der verschiedenen Funkendgeräte gemäß den Gewichten zu übertragen sind, die den jeweiligen verschiedenen Funkendgeräten entsprechen, die beim Formen einer Vielzahl von Raumvielfachkeulen zum Übertragen der Signale zwischen der Funkbasisstation und den Funkendgeräten verwendet werden; und
(b) Zuweisen der gesamten Rahmenkonfigurationsinformation, die Rahmenkonfigurationen aller der Zeitmultiplexrahmen anzeigt, an einen der Zeitmultiplexrahmen.

8. Rahmenkonfigurationsverfahren nach Anspruch 7, worin der Schritt (b) die gesamte Rahmenkonfigurationsinformation einem Rahmen zuweist, dem an alle Funkendgeräte (20) gleichzeitig zu übertragende Steuerinformation zugewiesen wird.

9. Rahmenkonfigurationsverfahren nach Anspruch 8, worin, wenn es eine Differenz zwischen Gesamtsummen der den Zeitmultiplexrahmen zugewiesenen Kommunikationsbandbreiten gibt, der Schritt (a) eine nächste Kommunikationsbandbreite einem Rahmen zuweist, für den eine Gesamtsumme von zugewiesenen Kommunikationsbandbreiten die kleinste unter den Zeitmultiplexrahmen ist.

10. Rahmenkonfigurationsverfahren nach Anspruch 9, worin der Schritt (a) die nächste zuzuweisende Kommunikationsbandbreite bestimmt, sodass eine Gesamtsumme von zugewiesenen Bandbreiten für einen unter den Zeitmultiplexrahmen im Voraus ausgewählten Referenzrahmen von einer Gesamtsumme von zugewiesenen Kommunikationsbandbreiten nicht für irgendwelche anderen Zeitmultiplexrahmen überschritten wird.

11. Rahmenkonfigurationsverfahren nach Anspruch 9, worin der Schritt (a) die Differenz zwischen den Gesamtsummen der Kommunikationsbandbreiten mit einem vorgeschriebenen Schwellenwert vergleicht.

12. Rahmenkonfigurationsverfahren nach Anspruch 11, worin der Schritt (a) die Gesamtsummen der Kommunikationsbandbreiten als identisch ansieht, wenn die Differenz zwischen den Gesamtsummen der Kommunikationsbandbreiten kleiner oder gleich dem vorgeschriebenen Schwellenwert ist.

13. Rahmenkonfigurationsverfahren für Zeitmultiplexrahmen zum Übertragen von Signalen zwischen einer Funkbasisstation (10) und einer Vielzahl von Funkendgeräten (20), wobei das Rahmenkonfigurationsverfahren umfasst:

(a) Zuweisen von Kommunikationsbandbreiten in verschiedenen Rahmen an verschiedene Funkendgeräte, sodass es im Wesentlichen keine gegenseitige Störung unter diesen Signalen gibt, die bezüglich der verschiedenen Funkendgeräte (20) gemäß Gewichten zu übertragen sind, die den jeweiligen verschiedenen Funkendgeräten (20) entsprechen, die beim Formen einer Vielzahl von Raumvielfachkeulen zum Übertragen der Signale zwischen der Funkbasisstation und den Funkendgeräten zu verwenden sind, und Zuweisen einer nächsten Kommunikationsbandbreite an einen Rahmen, für den eine Gesamtsumme von zugewiesenen Kommunikationsbandbreiten unter den Zeitmultiplexrahmen die kleinste ist; und
(b) Zuweisen einer Vielzahl von Rahmenkoufigurationsinformationen, deren jede eine Rahmenkonfiguration eines jeweiligen Zeitmultiplexrahmens anzeigt, an entsprechende der jeweiligen Zeitmultiplexrahmen.

14. Computerverwendbares Medium mit computerlesbaren Programmcodes, die darin ausgeführt sind, um einen Computer zu veranlassen, als eine Scheduling-Verarbeitungseinheit in einer Funkbasisstation (10) zu funktionieren, um Signale von Zeitmultiplexrahmen bezüglich einer Vielzahl von Funkendgeräten (20) zu übertragen, wobei die computerlesbaren Programmcodes Folgendes enthalten:

einen ersten computerlesbaren Programmcode, um den Computer zu veranlassen, die gesamte Rahmenkonfigurationsinformation, die Rahmenkonfigurationen aller Zeitmultiplexrahmen anzeigt, einem der Zeitmultiplexrahmen zuzuweisen oder eine Vielzahl von Rahmenkonfigurationsinformationen, deren jede eine Rahmenkonfiguration eines jeweiligen Zeitmultiplexrahmens anzeigt, entsprechenden der jeweiligen Zeitmultiplexrahmen zuzuweisen; und
einen zweiten computerlesbaren Programmcode, um den Computer zu veranlassen, Kommunikationsbandbreiten einer identischen Zeit in verschiedenen Rahmen verschiedenen Funkendgeräten zuzuweisen, sodass es im Wesentlichen keine gegenseitige Störung unter diesen Signalen gibt, die zur identischen Zeit bezüglich der verschiedenen Funkendgeräte gemäß Gewichten zu übertragen sind, die den

jeweiligen verschiedenen Funkendgeräten entsprechen, die beim Formen einer Vielzahl von Raumvielfachkeulen zum Übertragen der Signale zwischen der Funkbasisstation (10) und den Funkendgeräten (20) zu verwenden sind, oder Kommunikationsbandbreiten in verschiedenen Rahmen verschiedenen Funkendgeräten (20) zuzuteilen, sodass es im Wesentlichen keine gegenseitige Störung unter diesen Signalen gibt, die bezüglich der verschiedenen Funkendgeräte gemäß Gewichten zu übertragen sind, die den jeweiligen verschiedenen Funkendgeräten entsprechen, die beim Formen einer Vielzahl von Raumvielfachkeulen zum Übertragen der Signale zwischen der Funkbasisstation und den Funkendgeräten zu verwenden sind, und eine nächste Kommunikationsbandbreite einem Rahmen zuzuteilen, für den eine Gesamtsumme von zugewiesenen Kommunikationsbandbreiten die kleinste unter den Zeitmultiplexrahmen ist.

15. Trägermedium, das computerlesbare Anweisungen trägt, um den Computer zu steuern, das Verfahren nach einem der Ansprüche 7 bis 13 auszuführen.

Revendications

1. Station de base radio (10) pour transférer des signaux de trames multiplexées par répartition dans le temps relativement à une pluralité de terminaux radio (20), la station de base radio comportant :

une unité de formation de faisceaux (1003) configurée de manière à former une pluralité de faisceaux de répartition dans l'espace simultanément ;
une pluralité d'éléments d'antenne (12) configurée de manière à transférer les signaux relativement aux terminaux radio (20) en transmettant la pluralité de faisceaux de répartition dans l'espace vers les terminaux radio (20) ;
une unité de traitement de planification (1012) configurée de manière à affecter des largeurs de bande de communication aux terminaux radio (20) de sorte qu'il n'existe sensiblement aucun brouillage mutuel parmi ces signaux qui doivent être transférés par différentes trames, relativement à une pluralité de trames qui correspondent à au moins l'un de la pluralité de faisceaux de répartition dans l'espace ;
une unité de mémoire (1013) configurée de manière à stocker des pondérations correspondant respectivement aux terminaux radio, lesquelles doivent être utilisées pour former la pluralité de faisceaux de répartition dans l'espace ; et
une unité de commande de pondérations (1011) configurée de manière à définir les pondérations sur l'unité de formation de faisceaux ;

dans laquelle l'unité de traitement de planification (1012) est configurée de manière à affecter des largeurs de bande de communication d'un instant identique dans différentes trames à différents terminaux radio (20), de sorte qu'il n'existe sensiblement aucun brouillage mutuel parmi ces signaux qui doivent être transférés à l'instant identique relativement aux différents terminaux radio (20) selon les pondérations correspondant aux différents terminaux radio (20), telles que stockées dans l'unité de mémoire, et l'unité est ensuite configurée de manière à affecter des informations de configuration de trames complètes indiquant des configurations de trame de l'ensemble des trames multiplexées par répartition dans le temps à l'une des trames multiplexées par répartition dans le temps.

2. Station de base radio (10) selon la revendication 1, dans laquelle l'unité de traitement de planification (1012) est configurée de manière à planifier de sorte que les informations de configuration de trames complètes sont indiquées à l'ensemble des terminaux radio (20) simultanément.

3. Station de base radio (10) pour transférer des signaux de trames multiplexées par répartition dans le temps relativement à une pluralité de terminaux radio (20), la station de base radio (10) comportant :

une unité de formation de faisceaux (1003) configurée de manière à former une pluralité de faisceaux de répartition dans l'espace simultanément;
une pluralité d'éléments d'antenne (12) configurée de manière à transférer les signaux relativement aux terminaux radio (20) en transmettant la pluralité de faisceaux de répartition dans l'espace vers les terminaux radio (20) ; et
une unité de traitement de planification (1012) configurée de manière à affecter des largeurs de bande de communication aux terminaux radio (20) de sorte qu'il n'existe sensiblement aucun brouillage mutuel parmi ces signaux qui doivent être transférés par différentes trames, relativement à une pluralité de trames qui correspondent à au moins l'un de la pluralité de faisceaux de répartition dans l'espace ;
une unité de mémoire (1013) configurée de manière à stocker des pondérations correspondant respectivement aux terminaux radio, lesquelles doivent être utilisées pour former la pluralité de faisceaux de répartition dans l'espace ; et
une unité de commande de pondérations (1011) configurée de manière à définir les pondérations sur l'unité de formation de faisceaux (1003) ;

dans laquelle, l'unité de traitement de planification (1012) est configurée de manière à affecter des largeurs de bande de communication dans différentes trames à différents terminaux radio (20), de sorte qu'il n'existe sensiblement aucun brouillage mutuel parmi ces signaux qui doivent être transférés relativement aux différents terminaux radio (20) selon les pondérations correspondant aux différents terminaux radio, telles que stockées dans l'unité de mémoire, et l'unité affecte une largeur de bande de communication successive à une trame pour laquelle une somme totale de largeurs de bande de communication affectées est la plus petite parmi les trames multiplexées par répartition dans le temps ; et
dans laquelle l'unité de traitement de planification (1012) est configurée de manière à affecter une pluralité d'informations de configuration de trame indiquant chacune une configuration de trame d'une trame respective multiplexée par répartition dans le temps, à des trames correspondantes parmi les trames multiplexées par répartition dans le temps, respectivement.

4. Station de base radio selon la revendication 3, dans laquelle l'unité de traitement de planification (1012) est configurée de manière à planifier que la pluralité d'informations de configuration de trame est indiquée à l'ensemble des terminaux radio (20) simultanément.

5. Station de base radio selon l'une quelconque de revendications 1 ou 3, dans laquelle l'unité de traitement de planification (1012) est configurée de manière à traiter un groupe de terminaux radio présentant des pondérations similaires en tant qu'un terminal radio identique.

6. Station de base radio selon l'une quelconque de revendications 1 ou 3, dans laquelle l'unité de formation de faisceaux (1003) présente un circuit de formation de faisceau multiples configurée de manière à former la pluralité de faisceaux de répartition dans l'espace simultanément en pondérant les signaux devant être transmis ou reçus par les éléments d'antenne (12) en faisant appel aux pondérations définies par l'unité de commande de pondérations (1011).

7. Procédé de configuration de trames destiné à des trames multiplexées par répartition dans le temps pour transférer des signaux entre une station de base radio (10) et une pluralité de terminaux radio (20), le procédé de configuration de trames comportant les étapes ci-dessous consistant à :

(a) affecter des largeurs de bande de communication d'un instant identique dans différentes trames à différents terminaux radio (20), de sorte qu'il n'existe sensiblement aucun brouillage mutuel parmi ces signaux qui doivent être transférés à l'instant identique relativement aux différents terminaux radio selon des pondérations correspondant respectivement aux différents terminaux radio, lesquelles sont utilisées pour former une pluralité de faisceaux de répartition dans l'espace pour transférer les signaux entre la station de base radio et les terminaux radio ; et
(b) affecter des informations de configuration de trames complètes, indiquant des configurations de trame de l'ensemble des trames multiplexées par répartition dans le temps, à l'une des trames multiplexées par répartition dans le temps.

8. Procédé de configuration de trames selon la revendication 7, dans lequel l'étape (b) affecte les informations de configuration de trames complètes à une trame à laquelle sont affectées des informations de commande devant être transmises à l'ensemble des terminaux radio (20) simultanément.

9. Procédé de configuration de trames selon la revendication 8, dans lequel lorsqu'il existe une différence entre des sommes totales des largeurs de bande de communication affectées aux trames multiplexées par répartition dans le temps, l'étape (a) affecte une largeur de bande de communication successive à une trame pour laquelle une somme totale de largeur de bande de communication affectée est la plus petite parmi les trames multiplexées par répartition dans le temps.

10. Procédé de configuration de trames selon la revendication 9, dans lequel l'étape (a) détermine la largeur de bande de communication successive à affecter de sorte qu'une somme totale de largeurs de bande de communication affectées pour une trame de référence choisie au préalable parmi les trames multiplexées par répartition dans le temps n'est pas inférieure à une somme totale de largeurs de bande de communication affectées de quelconques autres trames multiplexées par répartition dans le temps.

11. Procédé de configuration de trames selon la revendication 9, dans lequel l'étape (a) compare la différence entre les sommes totales des largeurs de bande de communication à un seuil prescrit.

12. Procédé de configuration de trames selon la revendication 11, dans lequel, lorsque la différence entre les sommes totales des largeurs de bande de communication est inférieure ou égale au seuil prescrit, l'étape (a) considère les sommes totales des largeurs de bande de communication comme identiques.

13. Procédé de configuration de trames destinées à des trames multiplexées par répartition dans le temps pour transférer des signaux entre une station de base radio (10) et une pluralité de germinaux radio (20), le procédé de configuration de trames comportant les étapes ci-après consistant à :

(a) affecter des largeurs de bande de communication dans différentes trames à différents terminaux radio, de sorte qu'il n'existe sensiblement aucun brouillage mutuel parmi ces signaux qui doivent être transférés relativement aux différents terminaux radio (20) selon des pondérations correspondant respectivement aux différents terminaux radio (20), lesquelles doivent être utilisées pour former une pluralité de faisceaux de répartition dans l'espace en vue de transférer les signaux entre la station de base radio et les terminaux radio, et affecter une largeur de bande de communication successive à une trame pour laquelle une somme totale de largeurs de bande de communication affectées est la plus petite parmi les trames multiplexées par répartition dans le temps ; et
(b) affecter une pluralité d'informations de configuration de trame indiquant chacune une configuration de trame d'une trame respective multiplexée par répartition dans le temps, à des trames correspondantes parmi les trames multiplexées par répartition dans le temps, respectivement.

14. Support utilisable par un ordinateur présentant des codes de programme lisible par un ordinateur intégrés à celui-ci pour amener l'ordinateur à fonctionner en tant qu'une unité de traitement de planification dans une station de base radio (10) pour transférer des signaux de trames multiplexées par répartition dans le temps relativement à une pluralité de terminaux radio (20), les codes de programme lisible par un ordinateur comportant :

un premier code de programme lisible par un ordinateur pour amener l'ordinateur à affecter les informations de configuration de trames complètes indiquant des configurations de trame de l'ensemble des trames multiplexées par répartition dans le temps à l'une des trames multiplexées par répartition dans le temps, ou à affecter une pluralité d'informations de configuration de trame, indiquant chacune une configuration de trame d'une trame respective multiplexée par répartition dans le temps, à des trames correspondantes parmi les trames multiplexées par répartition dans le temps respectivement, et
un second code de programme lisible par un ordinateur pour amener l'ordinateur à affecter des largeurs de bande de communication d'un instant identique dans différentes trames à différents terminaux radio, de sorte qu'il n'existe sensiblement aucun brouillage mutuel parmi ces signaux qui doivent être transférés à l'instant identique relativement aux différents terminaux radio selon des pondérations correspondant respectivement aux différents terminaux radio, lesquelles doivent être utilisées pour former une pluralité de faisceaux de répartition dans l'espace pour transférer les signaux entre la station de base radio (10) et les terminaux radio (20), ou à affecter des largeurs de bande de communication dans différentes trames à différents terminaux radio (20), de sorte qu'il n'existe sensiblement aucun brouillage mutuel parmi ces signaux qui doivent être transférés relativement aux différents terminaux radio selon des pondérations correspondant respectivement aux différents terminaux radio, lesquelles doivent être utilisées pour former une pluralité de faisceaux de répartition dans l'espace pour transférer les signaux entre la station de base radio et les terminaux radio et affecter une largeur de bande de communication successive à une trame pour laquelle une somme totale de largeurs de bande de communication affectées est la plus petite parmi les trames multiplexées par répartition dans le temps.

15. Support informatique transportant des instructions lisibles par un ordinateur pour amener l'ordinateur à mettre en oeuvre le procédé selon l'une quelconque des revendications 7 à 13.

FIG. 1

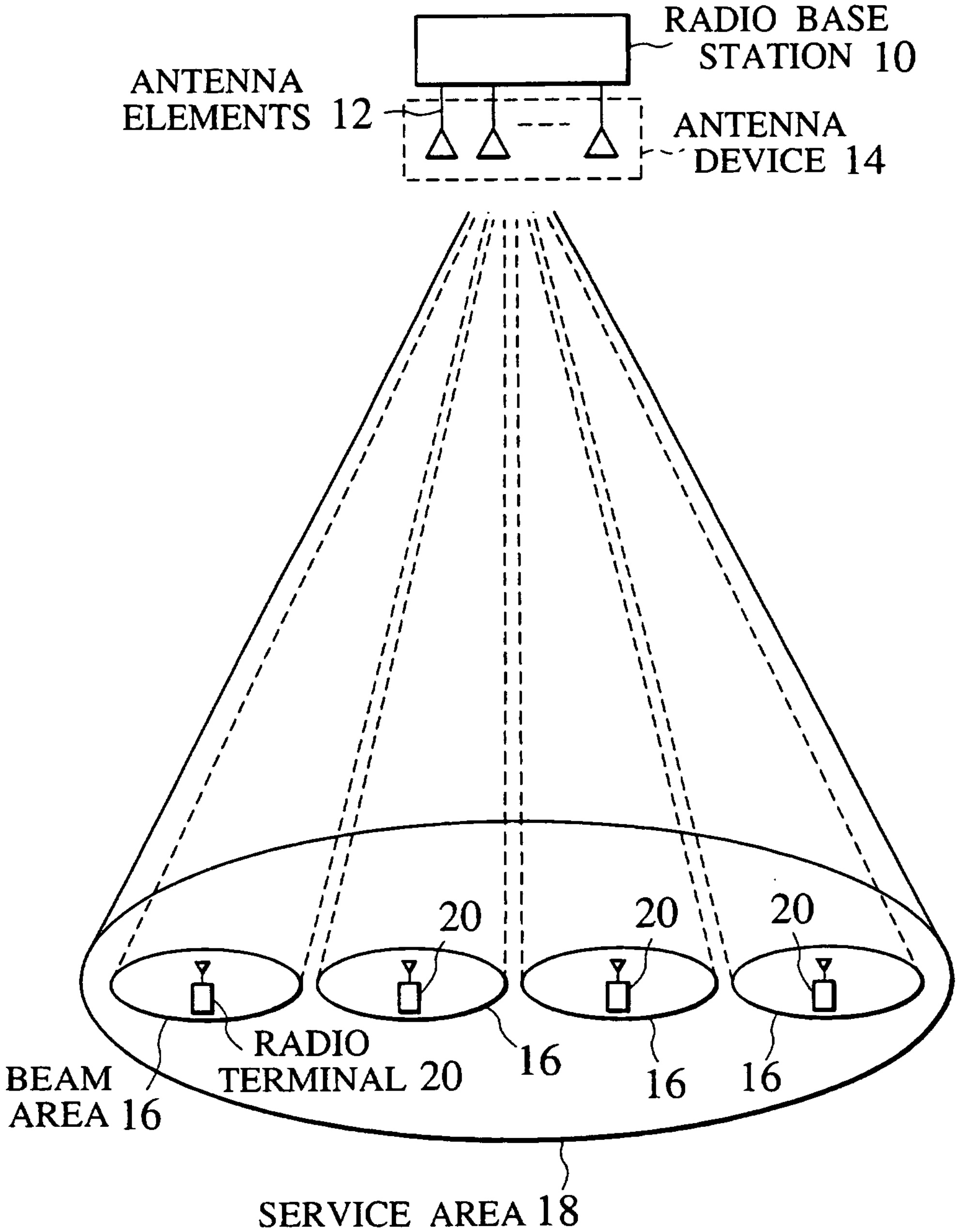

RADIO BASE
STATION 10
ANTENNA
ELEMENTS 12
ANTENNA
DEVICE 14
20
20
20
RADIO
TERMINAL 20
16
16
16
BEAM
AREA 16
SERVICE AREA 18

FIG. 2

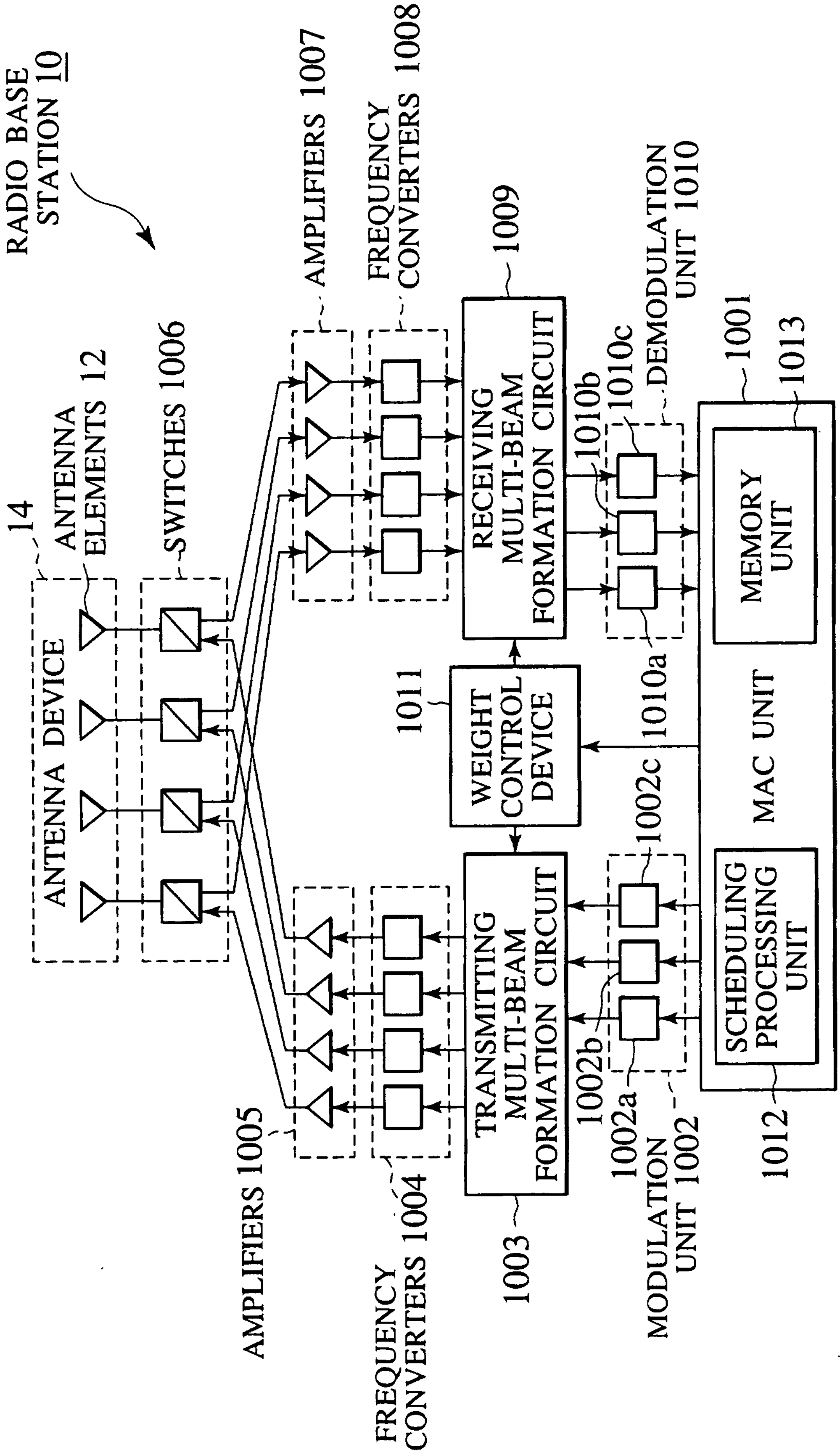

RADIO BASE STATION 10
ANTENNA DEVICE
14
ANTENNA ELEMENTS 12
SWITCHES 1006
AMPLIFIERS 1007
FREQUENCY CONVERTERS 1008
1009
RECEIVING MULTI-BEAM FORMATION CIRCUIT
DEMODULATION UNIT 1010
1010a
1010b
1010c
1001
1013
MEMORY UNIT
MAC UNIT
1011
WEIGHT CONTROL DEVICE
TRANSMITTING MULTI-BEAM FORMATION CIRCUIT
1003
1002a
1002b
1002c
MODULATION UNIT 1002
SCHEDULING PROCESSING UNIT
1012
AMPLIFIERS 1005
FREQUENCY CONVERTERS 1004

FIG. 3

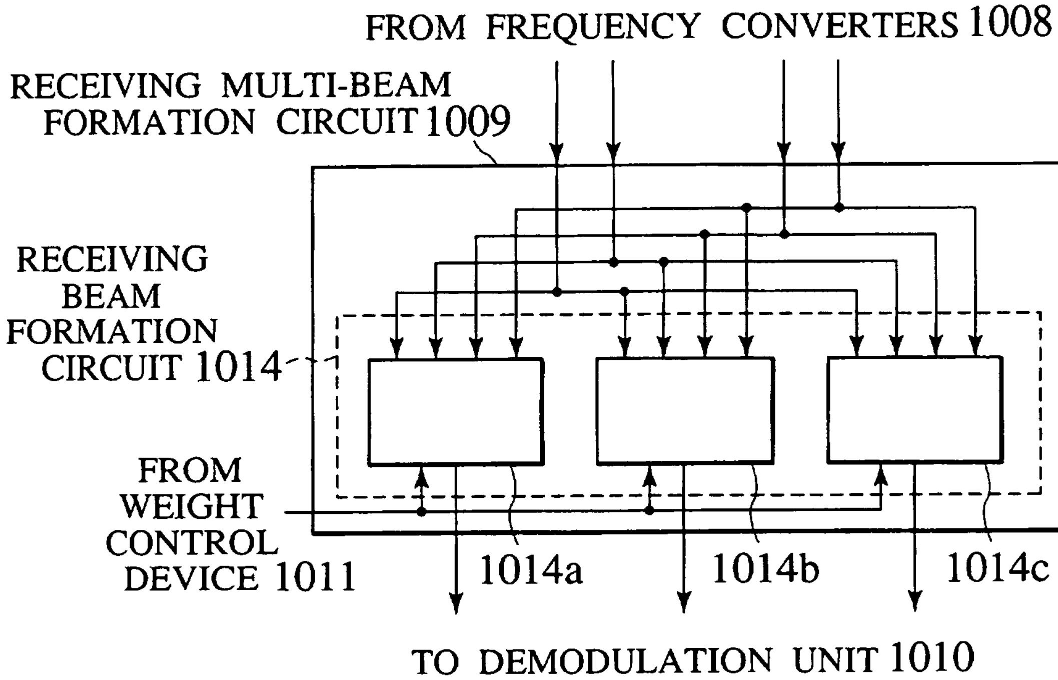

FROM FREQUENCY CONVERTERS 1008
RECEIVING MULTI-BEAM FORMATION CIRCUIT 1009
RECEIVING BEAM FORMATION CIRCUIT 1014
FROM WEIGHT CONTROL DEVICE 1011
1014a
1014b
1014c
TO DEMODULATION UNIT 1010

FIG. 4

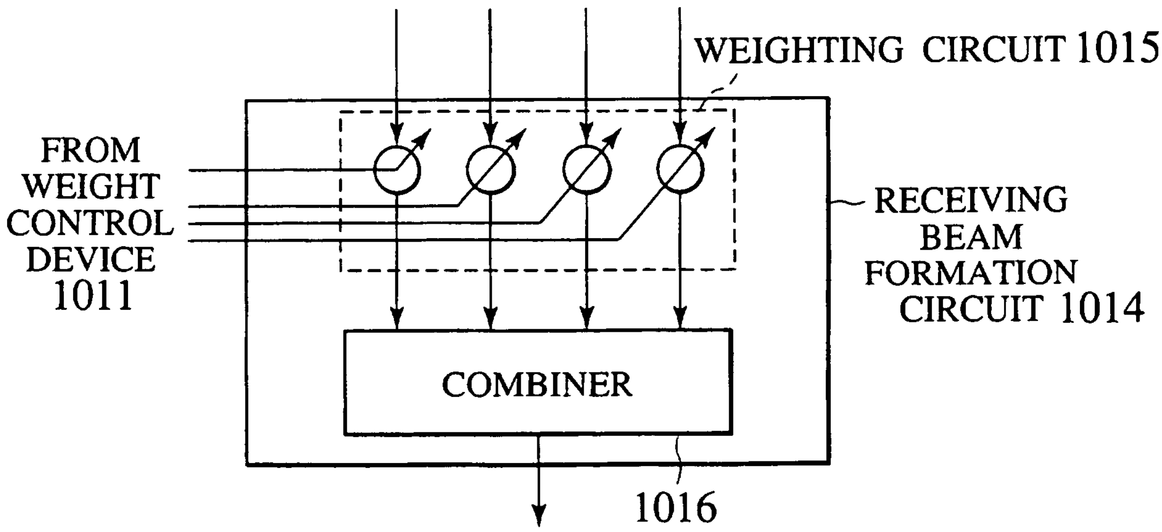

WEIGHTING CIRCUIT 1015
FROM WEIGHT CONTROL DEVICE 1011
RECEIVING BEAM FORMATION CIRCUIT 1014
COMBINER
1016

FIG. 5

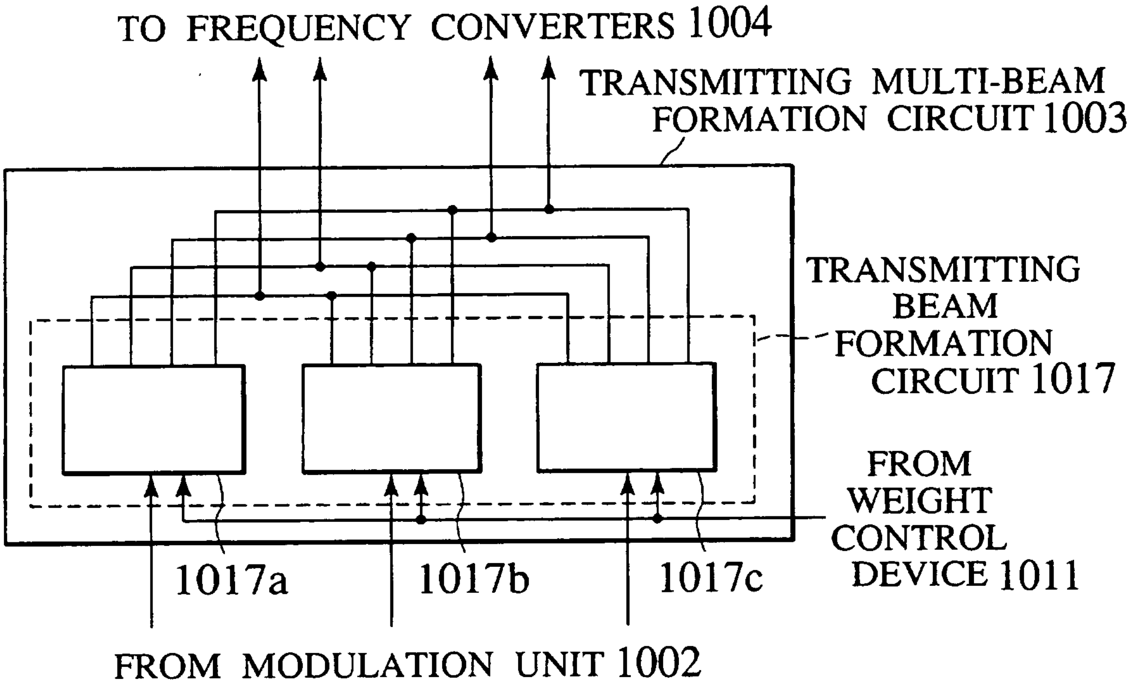

TO FREQUENCY CONVERTERS 1004
TRANSMITTING MULTI-BEAM FORMATION CIRCUIT 1003
TRANSMITTING BEAM FORMATION CIRCUIT 1017
FROM WEIGHT CONTROL DEVICE 1011
1017a
1017b
1017c
FROM MODULATION UNIT 1002

FIG. 6

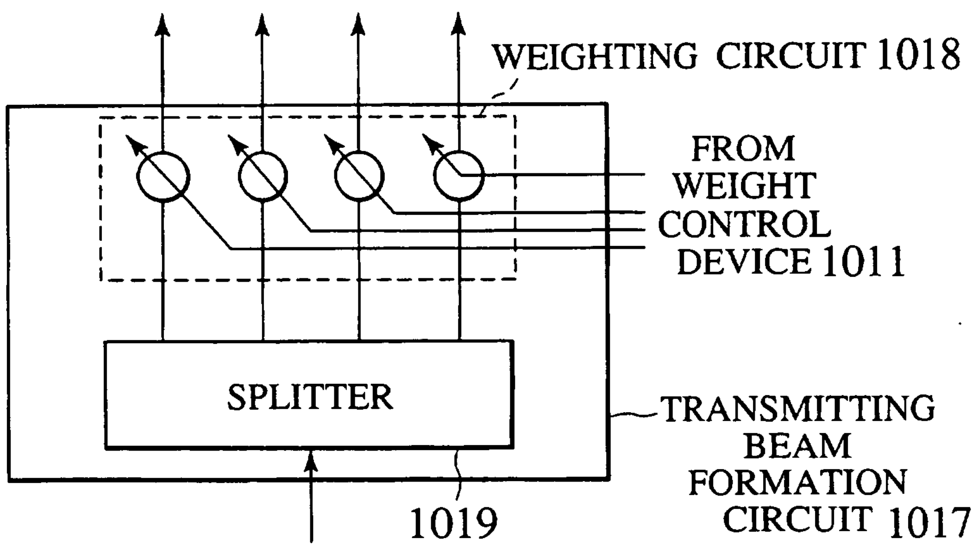

WEIGHTING CIRCUIT 1018
FROM WEIGHT CONTROL DEVICE 1011
SPLITTER
TRANSMITTING BEAM FORMATION CIRCUIT 1017
1019

FIG. 7

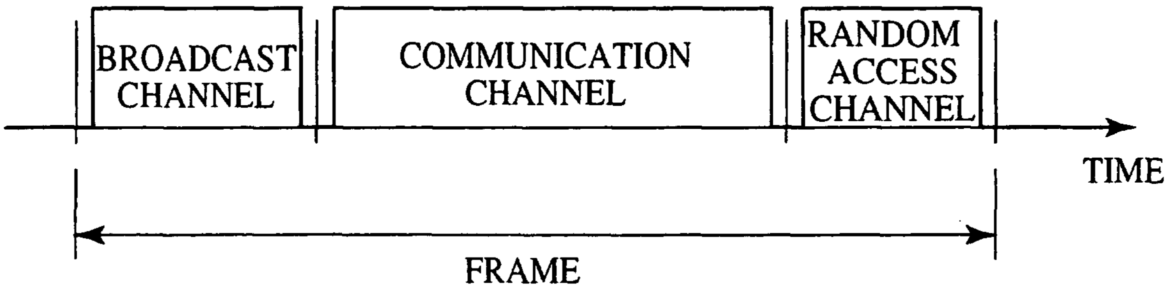
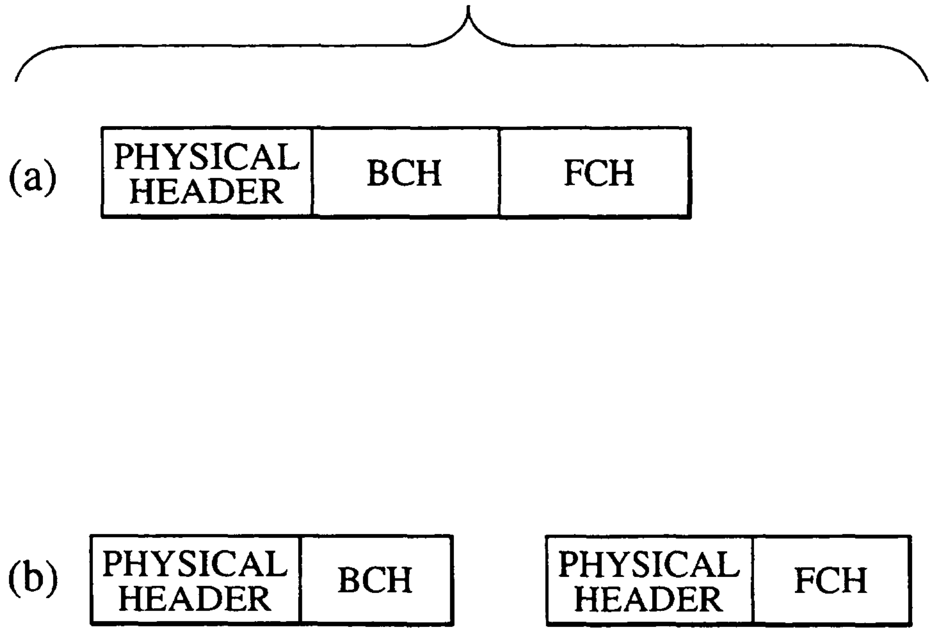


FIG. 8



BCH : BROADCAST CHANNEL
FCH : FRAME CHANNEL

FIG. 9

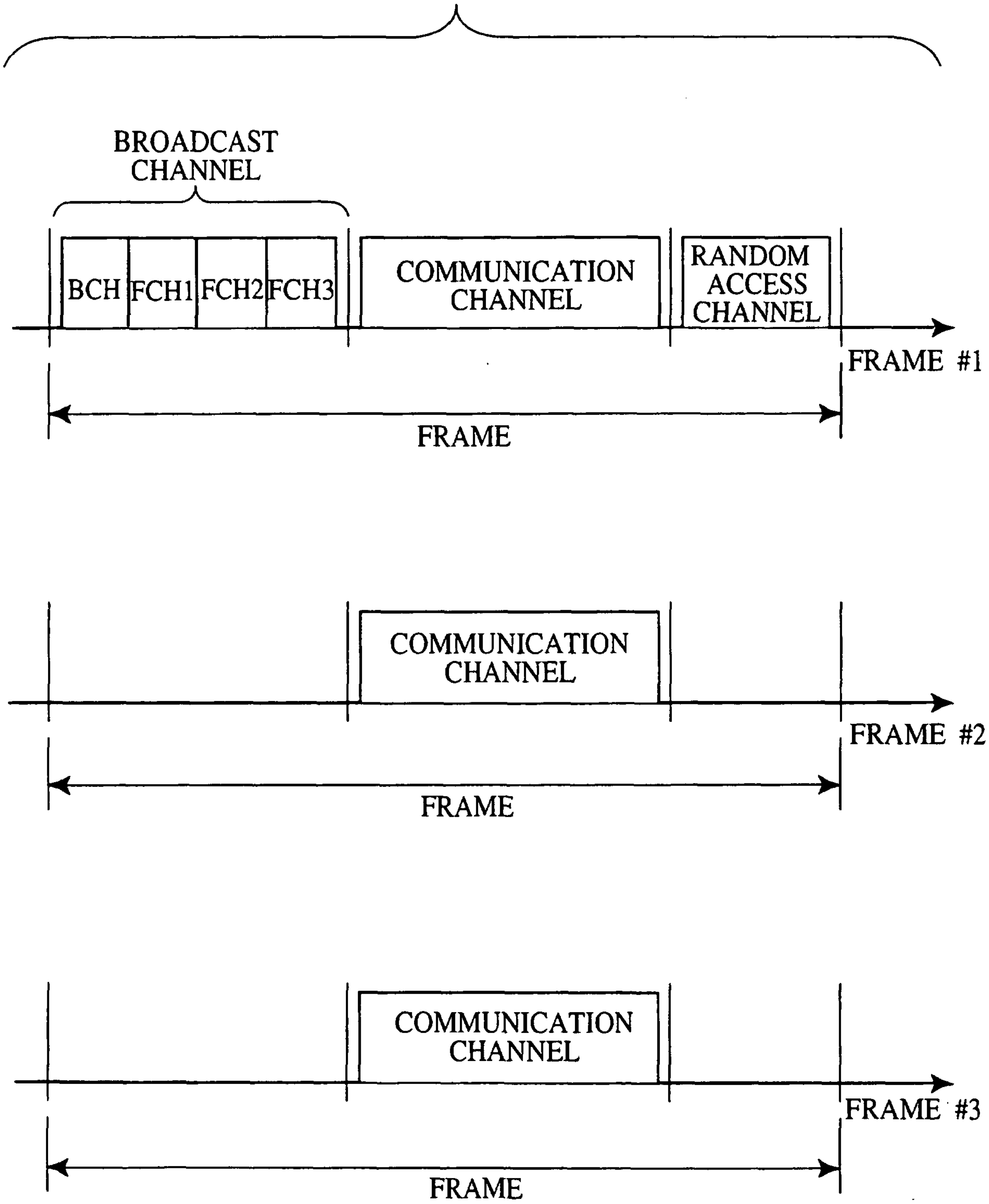

BROADCAST CHANNEL
BCH
FCH1
FCH2
FCH3
COMMUNICATION CHANNEL
RANDOM ACCESS CHANNEL
FRAME #1
FRAME
COMMUNICATION CHANNEL
FRAME #2
FRAME
COMMUNICATION CHANNEL
FRAME #3
FRAME

FIG. 10

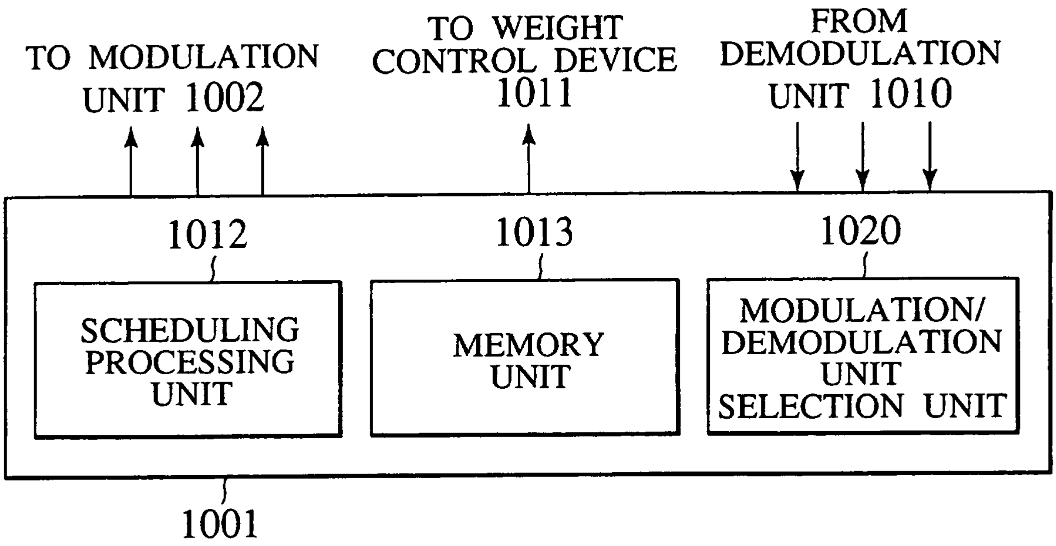

TO MODULATION UNIT 1002
TO WEIGHT CONTROL DEVICE 1011
FROM DEMODULATION UNIT 1010
1012
1013
1020
SCHEDULING PROCESSING UNIT
MEMORY UNIT
MODULATION/ DEMODULATION UNIT SELECTION UNIT
1001

FIG. 11

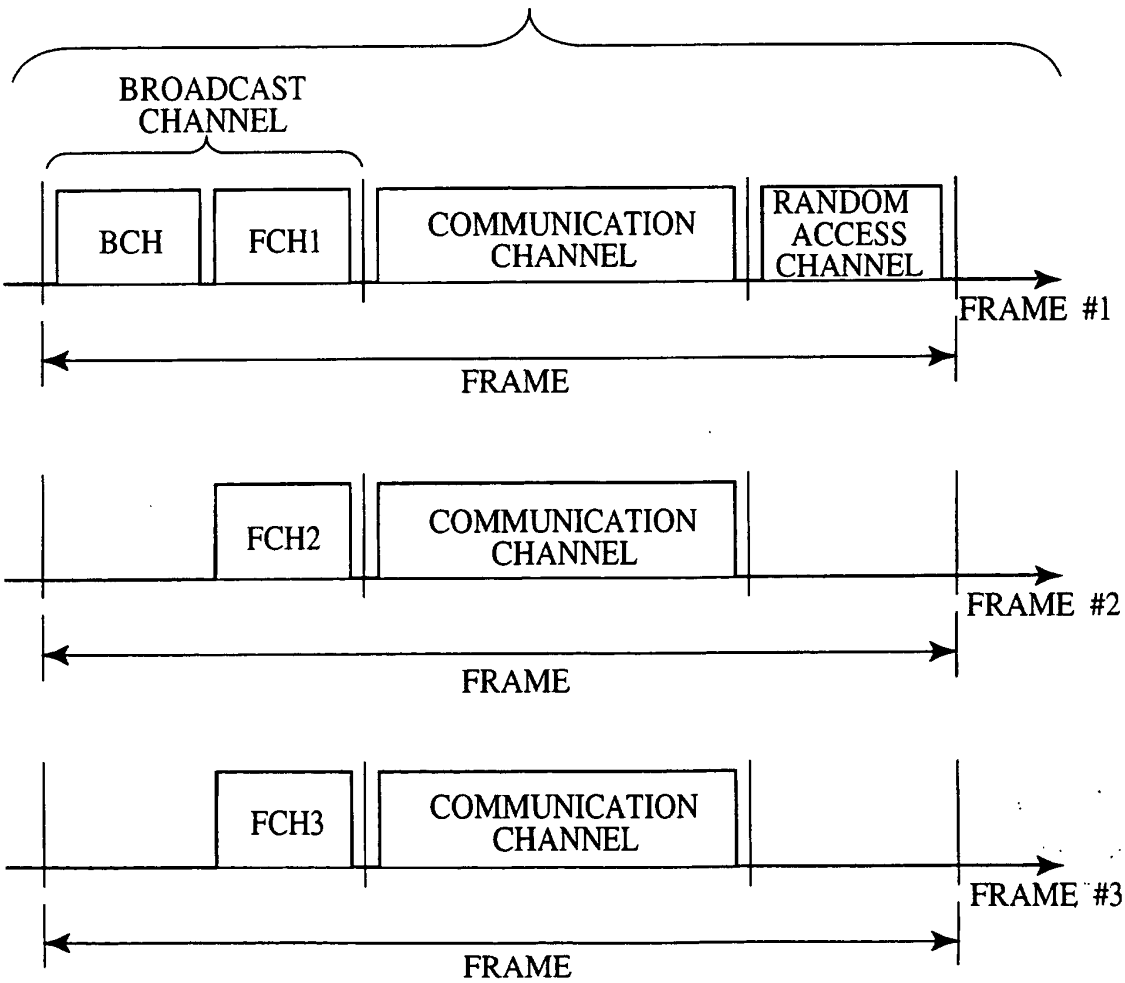

BROADCAST CHANNEL
BCH
FCH1
COMMUNICATION CHANNEL
RANDOM ACCESS CHANNEL
FRAME #1
FRAME
FCH2
COMMUNICATION CHANNEL
FRAME #2
FRAME
FCH3
COMMUNICATION CHANNEL
FRAME #3
FRAME

FIG. 12A

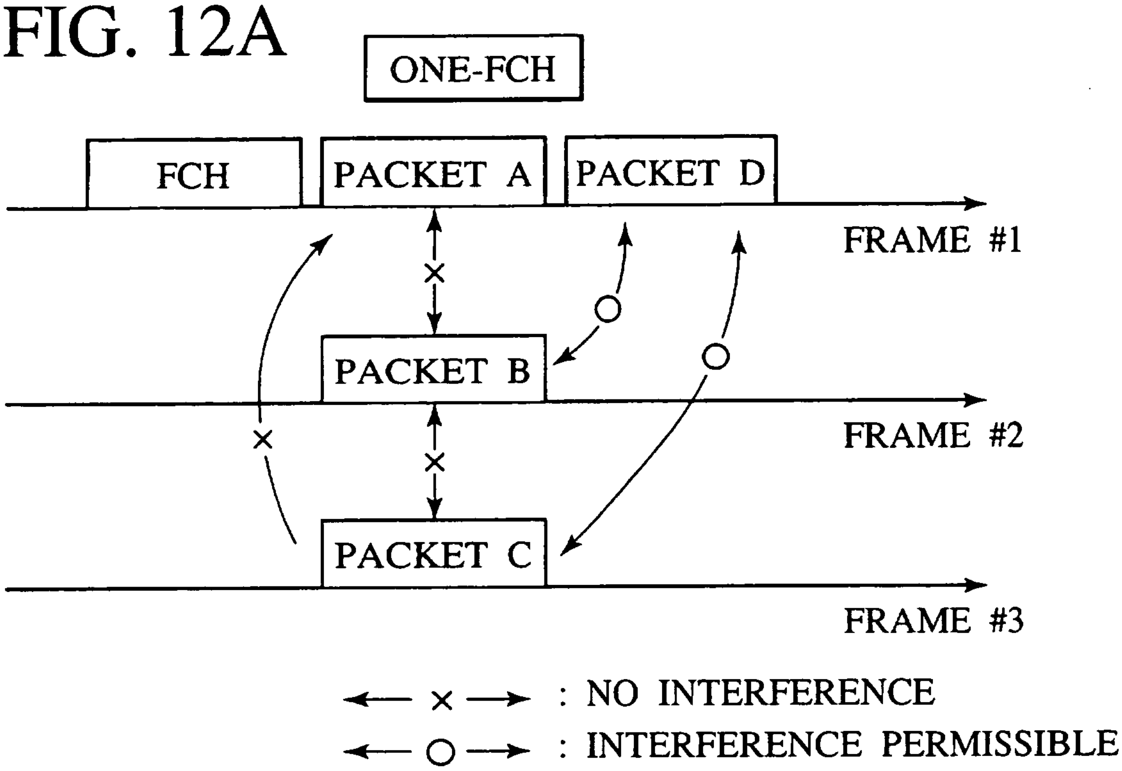


FIG. 12B

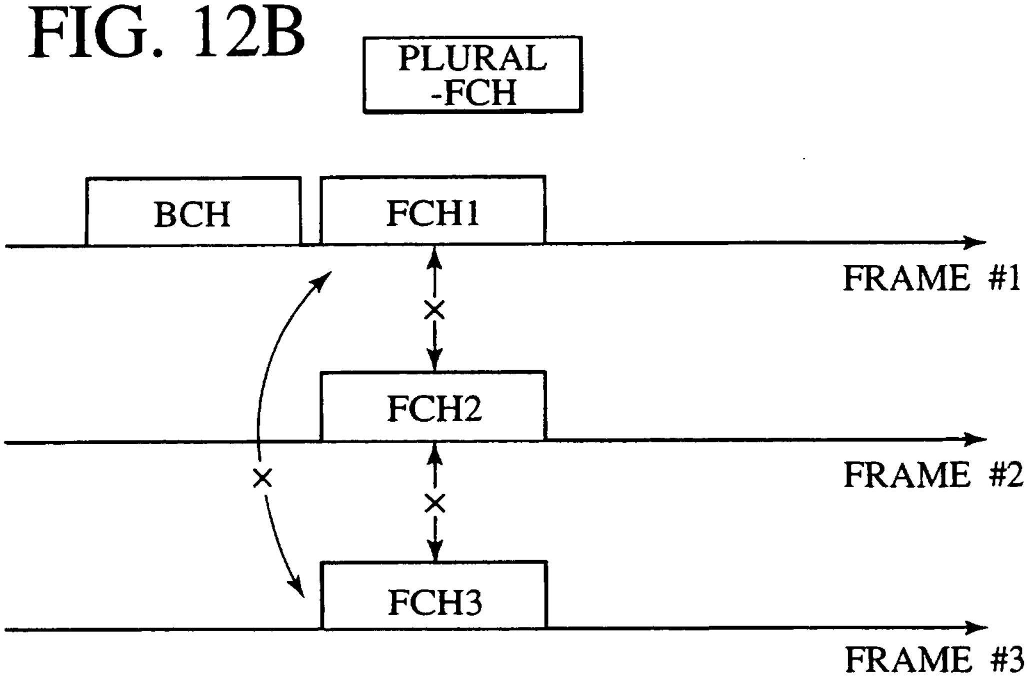


FIG. 13

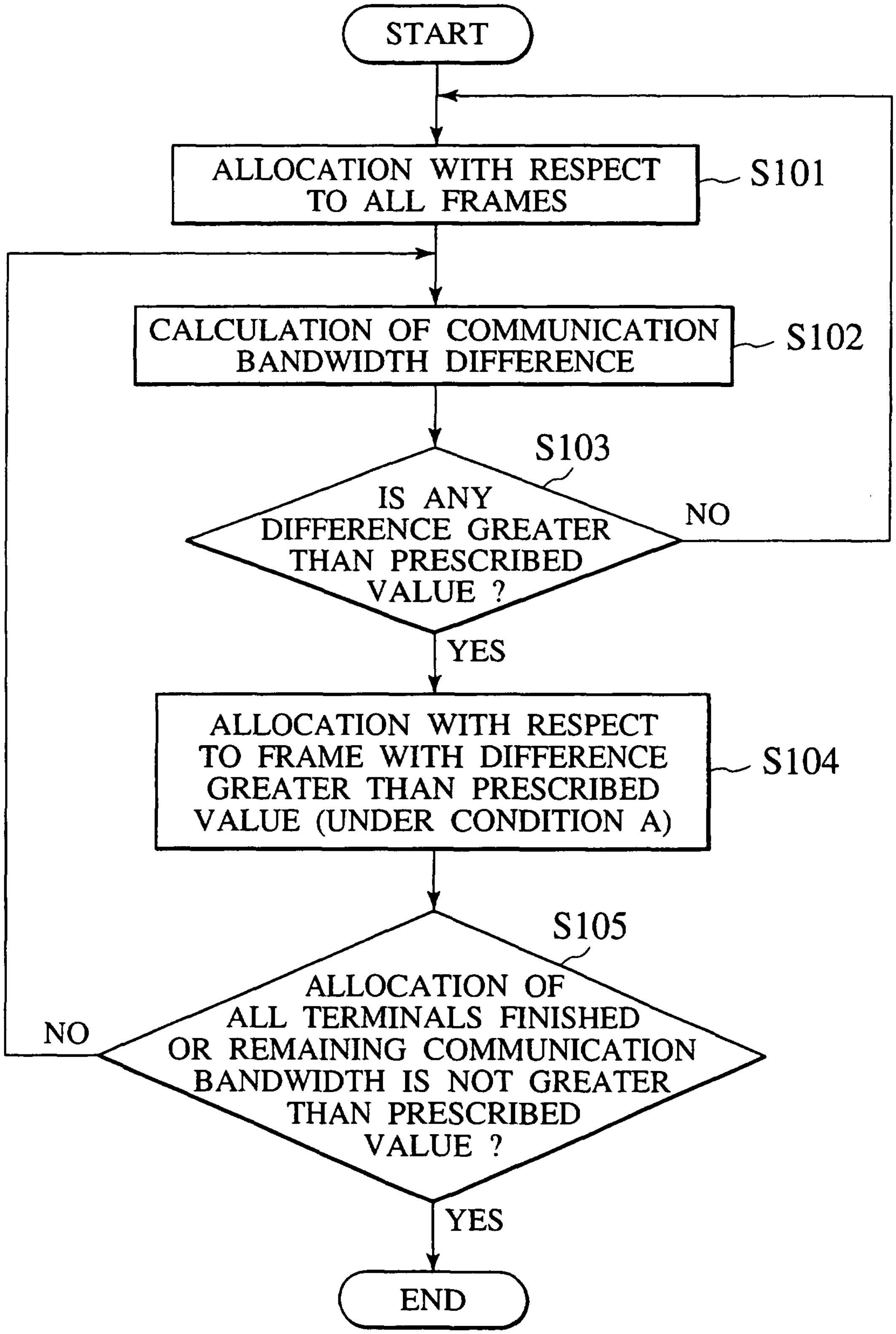

START
ALLOCATION WITH RESPECT TO ALL FRAMES
S101
CALCULATION OF COMMUNICATION BANDWIDTH DIFFERENCE
S102
S103
IS ANY DIFFERENCE GREATER THAN PRESCRIBED VALUE ?
NO
YES
ALLOCATION WITH RESPECT TO FRAME WITH DIFFERENCE GREATER THAN PRESCRIBED VALUE (UNDER CONDITION A)
S104
S105
ALLOCATION OF ALL TERMINALS FINISHED OR REMAINING COMMUNICATION BANDWIDTH IS NOT GREATER THAN PRESCRIBED VALUE ?
NO
YES
END

FIG. 14

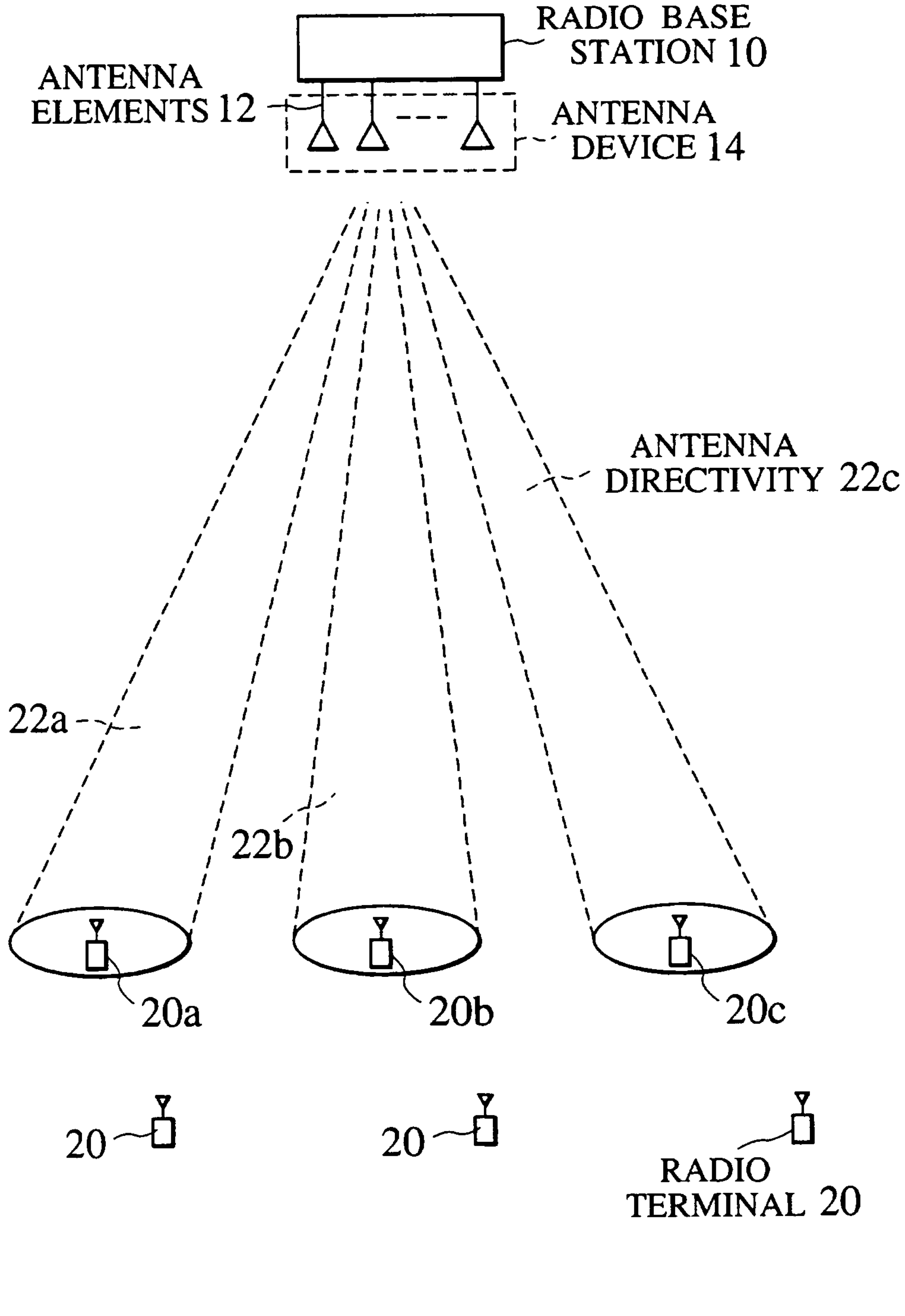

RADIO BASE
STATION 10
ANTENNA
ELEMENTS 12
ANTENNA
DEVICE 14
ANTENNA
DIRECTIVITY 22c
22a
22b
20a
20b
20c
20
20
RADIO
TERMINAL 20

FIG. 15A

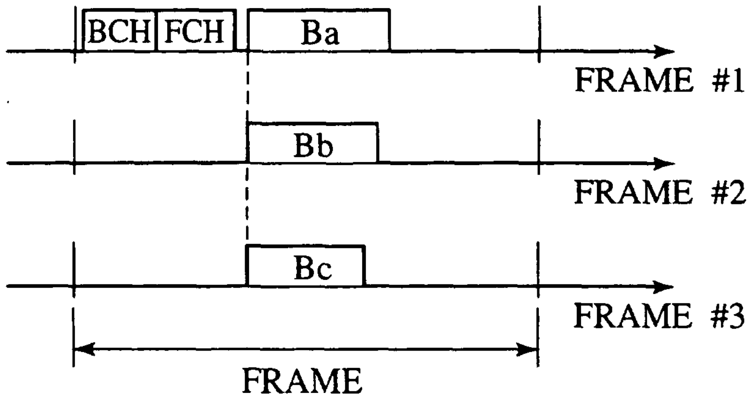


FIG. 15B

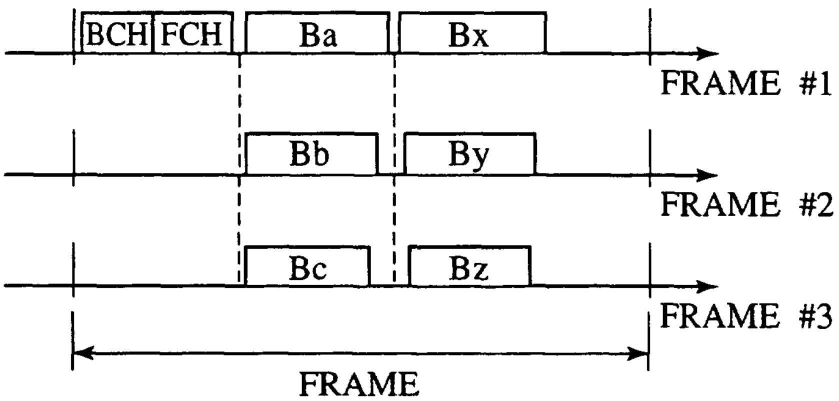


FIG. 15C

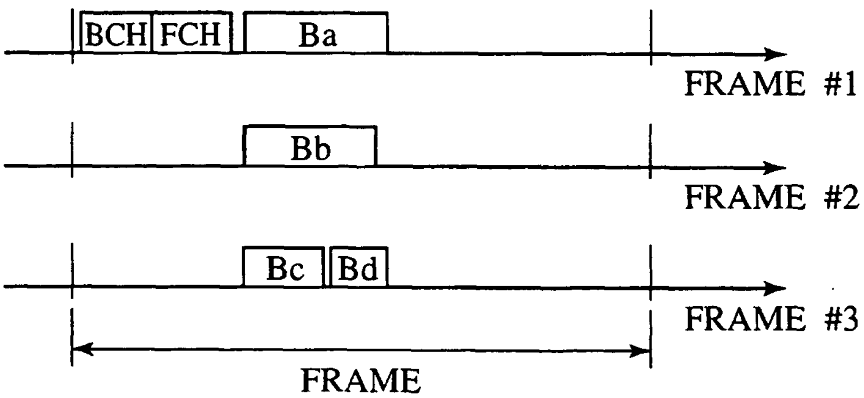


FIG. 16

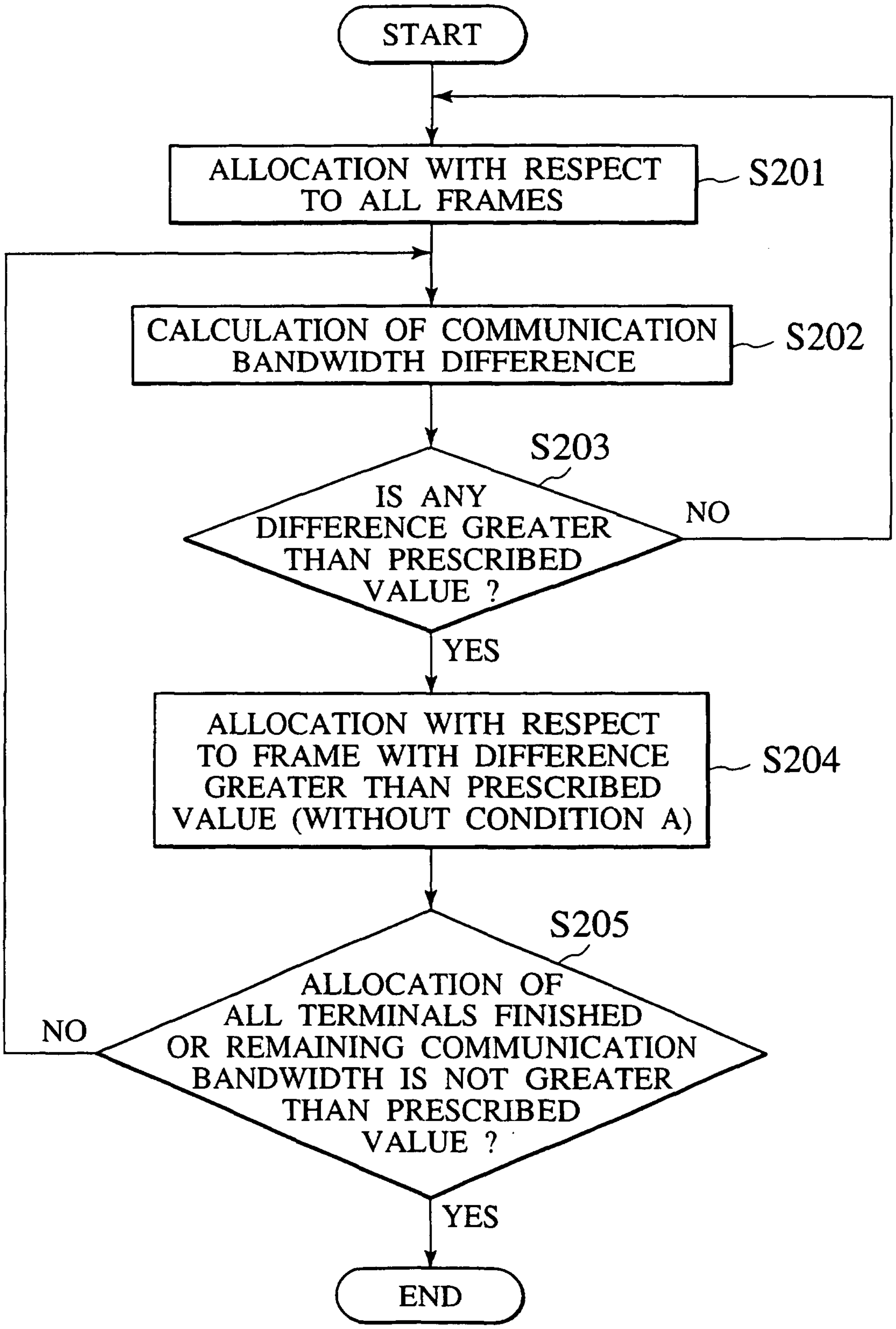

START
ALLOCATION WITH RESPECT TO ALL FRAMES
S201
CALCULATION OF COMMUNICATION BANDWIDTH DIFFERENCE
S202
S203
IS ANY DIFFERENCE GREATER THAN PRESCRIBED VALUE ?
NO
YES
ALLOCATION WITH RESPECT TO FRAME WITH DIFFERENCE GREATER THAN PRESCRIBED VALUE (WITHOUT CONDITION A)
S204
S205
ALLOCATION OF ALL TERMINALS FINISHED OR REMAINING COMMUNICATION BANDWIDTH IS NOT GREATER THAN PRESCRIBED VALUE ?
NO
YES
END

FIG. 17A

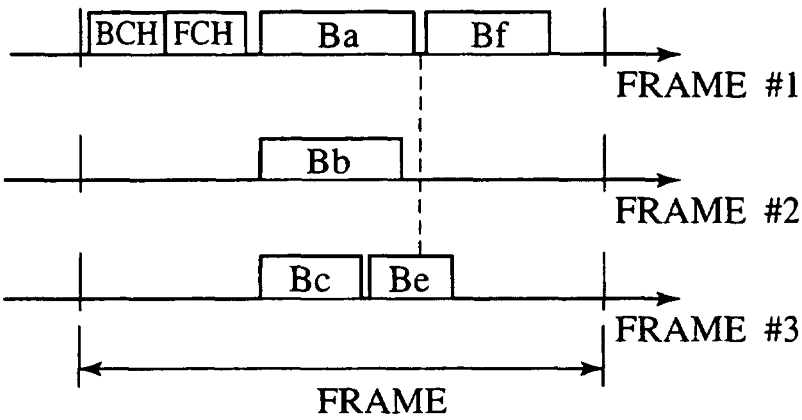


FIG. 17B

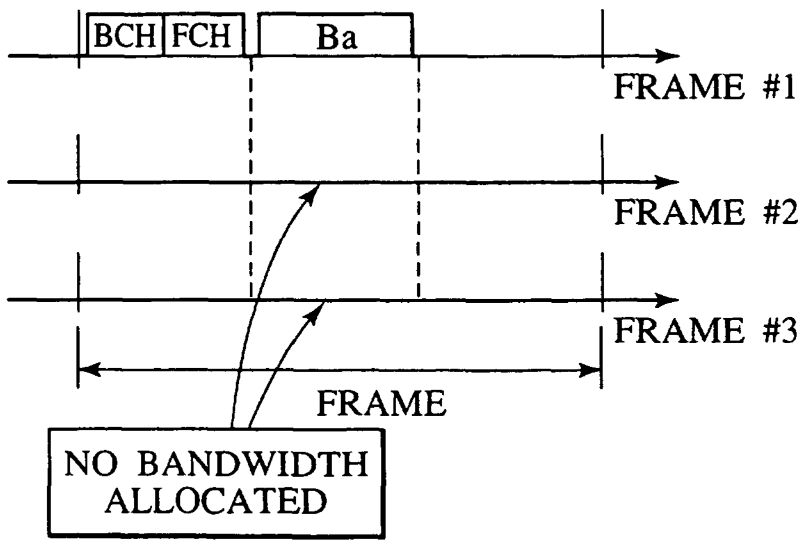


FIG. 18

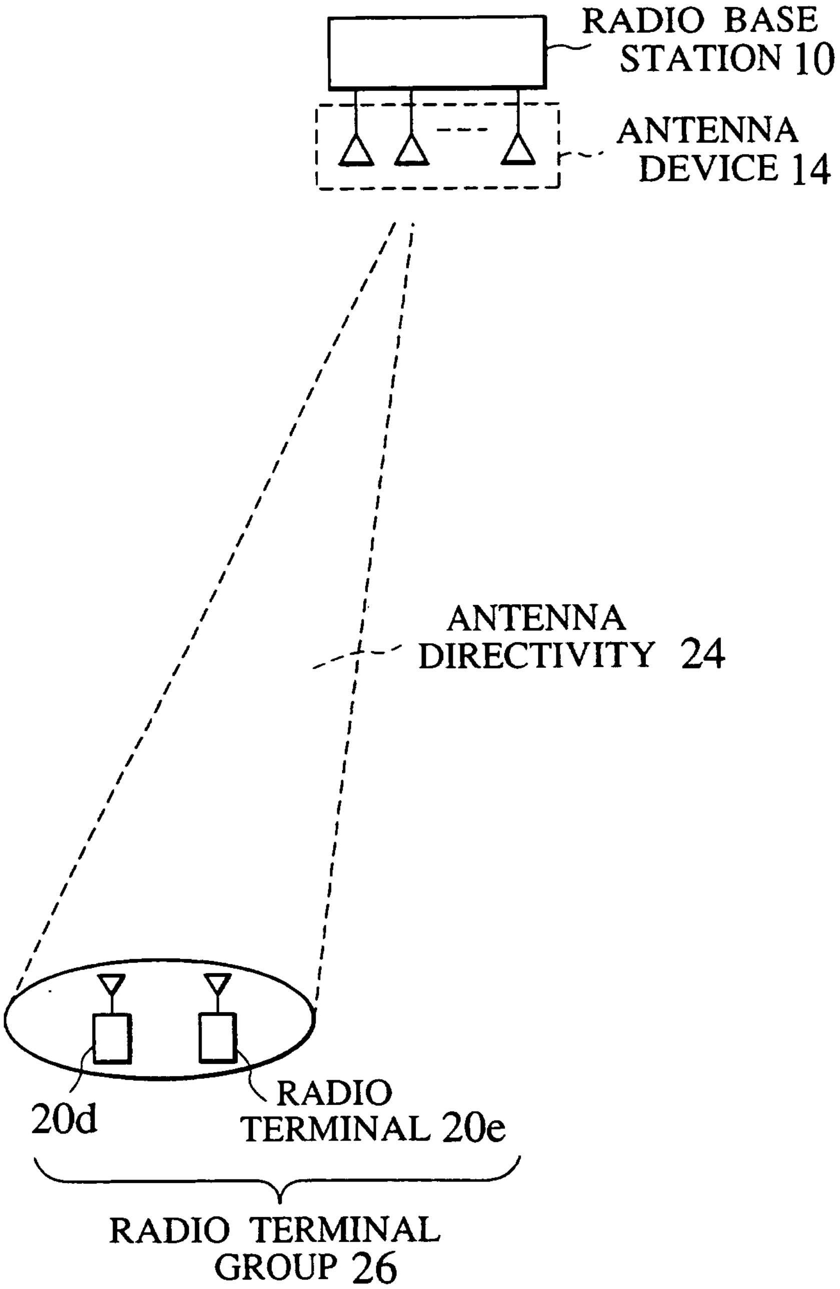

RADIO BASE
STATION 10
ANTENNA
DEVICE 14
ANTENNA
DIRECTIVITY 24
20d
RADIO
TERMINAL 20e
RADIO TERMINAL
GROUP 26

FIG. 19

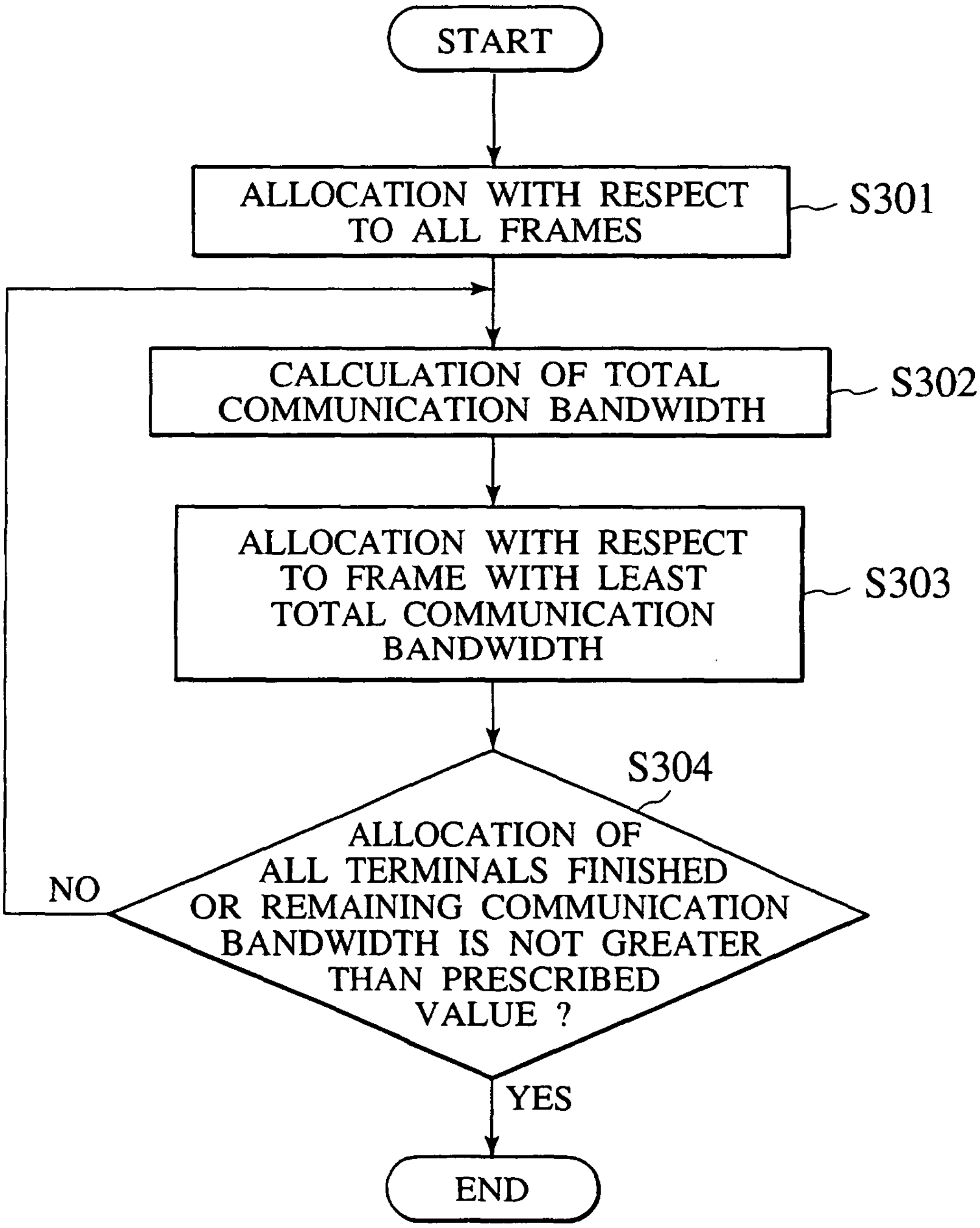

START
ALLOCATION WITH RESPECT TO ALL FRAMES
S301
CALCULATION OF TOTAL COMMUNICATION BANDWIDTH
S302
ALLOCATION WITH RESPECT TO FRAME WITH LEAST TOTAL COMMUNICATION BANDWIDTH
S303
S304
ALLOCATION OF ALL TERMINALS FINISHED OR REMAINING COMMUNICATION BANDWIDTH IS NOT GREATER THAN PRESCRIBED VALUE ?
NO
YES
END

FIG. 20A

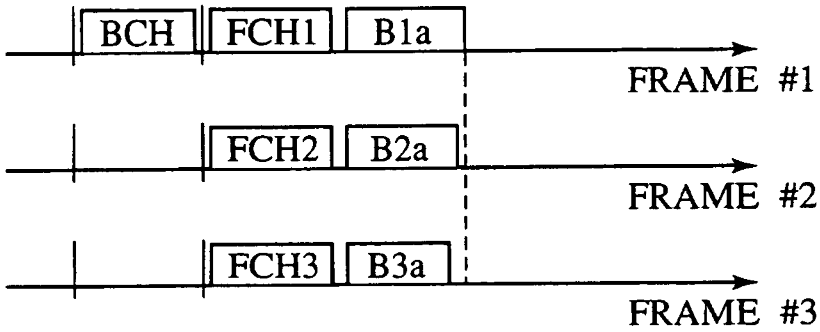
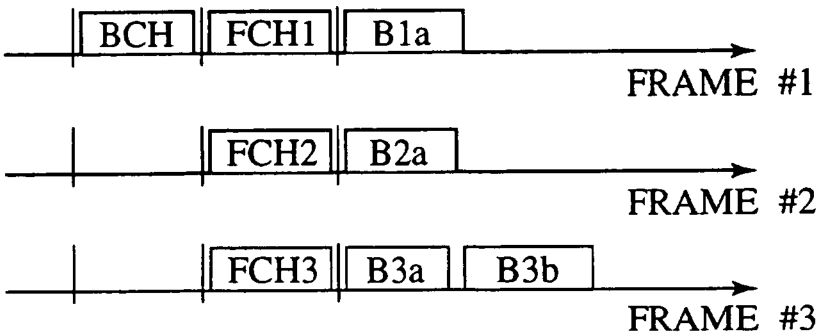


FIG. 20B



REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Non-patent literature cited in the description

- **Sinha et al.** Forward link capacity in smart antenna base stations with dynamic slot allocation. *the 9th IEEE International Symposium ''Personal, indoor and mobile radio communications 1998,* 942-946 **[0005]**